SUB-SECTION-IV-D

CIVIL WORKS

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**GENERAL**
1.01.00	This section of the bidding document deals mainly with the technical specification for the design and preparation of detailed drawings, getting the design and drawings approved by the Employer, fabrication, erection and construction of the necessary civil, structural and architectural works associated with the FGD package for **North Karanpura STPP (3x660 MW)**. The work shall have to be carried out both below and above ground level and shall be involving, basements, equipment foundations, grounding, slabs, beams, columns, footings, rafts, walls, steel frames, brick walls, stairs, trenches, pits, access roads, culverts, trestles, silos, sumps, Limestone storage hopper & shed, Crusher House, Transfer points, Conveyor Galleries, Tunnels, Gypsum storage shed, Chimney, Gypsum dewatering building, Ball Mill building, FGD control room building, Tank Foundations, absorber tower foundation, transformer foundation, MCC Building, finishes, complete architectural aspects, drainage, sanitation, water supply (from terminal points to various buildings/facilities) and all other civil, structural and architectural works associated with the complete FGD package.
1.02.00	The specifications are intended for the general description of the work, quality and workmanship. The specifications are not, however, intended to cover minutest details and the work shall be executed according to the relevant latest Indian Standard Codes / I. R. S. / I. R. C. specifications. In absence of the above, the work shall be executed according to the best prevailing local Public Works Department practices or to the recommendations of relevant American and British Standards or to the instructions of the Engineer. Some of the relevent I. S. Codes to be followed is mentioned in the Technical Specifications. The Contractor is expected to get clarified on any doubts about the specifications, etc. before bidding, in writing with the Employer in respect of interpretation of any portions of this document.
1.03.00	Bidder or his agencies engaged as detailer for fabrication drawings should have the experience of detailing for power plant structures or steel plant or Industrial structures like Petro/ Chemical/ Refinery/ Cement/FGD Plant/Coal Handling Plant/Ash Handling Plant etc. The designer responsible for preparation of scope drawings shall review and approve the fabrication drawings prepared by the detailer before releasing them for fabrication.
2.00.00	**Sub QR for Civil Works:**
2.01.00	Bidder or its agency should have in past executed civil and structural works for 500 MW or higher capacity coal based/Lignite based power plant including earthwork in filling involving mechanical compaction and cutting in hard rock, foundations, Bulk material handling plant involving underground storage hopper and underground tunnels.
2.02.00	Bidder can engage more than one agency, in case the Bidder itself is not able to meet the requirement at 2.01.00. The agency being engaged for a particular work should have in the past executed such works of 500 MW or higher capacity plant.

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2.03.00	For Chimney, Bidder or its agency should have in the past built at least one (1) reinforced concrete chimney of minimum 100m height.
2.04.00	In case Bidder or its agency do not meet the requirements at 2.01.00 and the Bidder proposes to engage agency (ies) for civil & structural works on work volume basis (except for Chimney), Bidder or its agency (ies) should have executed such works in the past and the annual rate of execution in the reference works should not be less than eighty percent (80%) of the asking rate of such works, (structural steel fabrication & erection, RCC, earthwork in filling involving mechanical compaction and cutting in hard rock, RCC in underground storage hopper and underground tunnels) for which it is being engaged. Successful Bidder shall finalize the agency (ies) for each work in consultation with Engineer-in-charge at site before engaging them.
	Design agency for Civil & Steel Structural Works:
2.05.00	Bidder or its agency (ies) should have carried out the design and detailed engineering of following works: (i) Civil & Structural works associated with at least one bulk material handling plant for 500 MW or higher capacity coal based/Lignite based power plant. (ii) For Chimney, Bidder or its design agency (ies) should have carried out design & detailed engineering of at least one reinforced concrete chimney with steel flues, of minimum 100m height. (iii) Machine foundations such as Mill foundations/ Block foundations.
2.06.00	Bidder can engage more than one agency (of repute), in case the Bidder itself is not able to meet the requirement at 2.05.00. The design agency (ies) proposed by the Bidder shall be subject to Employer's approval.
3.00.00	**Work Description**
3.01.00	**Truck Hopper, Limestone Storage hopper and Underground Tunnel** Truck Hopper shall consist of underground portion, which shall be of R. C. C. with structural steel shed covered with permanently Colour coated profiled steel sheets. Limestone storage hopper shall be of RCC with structural steel shed covered with permanently Colour coated profiled steel sheets. The structural arrangement to be adopted for the design and construction of Limestone Storage hopper shall essentially consist of R. C. C. frames spaced at approx. 3.0M centers with R. C. C. wall panels on the sides and R. C. C. raft at the bottom, fixed to the frames. Minimum thickness of R. C. C. raft at bottom shall be 600

mm. Minimum thickness of RCC side walls shall be 600 mm at bottom and 300 mm at top.

The vertical and inclined portion of hopper shall be provided with 50 mm thick guniting (shotcreting). Details of shotcreting have been given elsewhere in this specification.

Expansion joints shall be provided at a maximum distance of 40m. 600 mm wide water stop fabricated with 22G copper plate with bitumen board fillers and polysulphide sealing compound as specified elsewhere shall be used as expansion joint material.

Floor shall be provided with cross slope not flatter than 1 in 50 towards side drains. Side drains shall be sloped towards sump where sump pumps as specified elsewhere, shall be provided. The slope of side drains shall not be flatter than 1 in 400. Side drains and sump shall have removable type steel grating cover.

Water proofing / Damp proofing of under ground Truck hopper, Limestone Storage hopper, tunnels and underground (i. e. basement) portion of transfer houses shall be done by providing the following treatments:

Chemical injection grouting for inner faces (details as specified elsewhere).

Polymer modified cementitious coating on earth side face as per the following :

(1) On the outer surface of walls, frames and roof slabs coming in contact with earth, polymer modified cementitious coating in two layers as specified and as per manufacturer's specifications shall be provided directly on the concrete surface.

(2) 50 mm thick P. C. C. (1 : 2 : 4 with 10 mm nominal size stone aggregates) shall be provided under the raft i.e. over the lean concrete, followed by polymer modified cementitious coating in two layers (slurry mix application) as per manufacturer's specification. 50 mm thick P. C. C. (1 : 2 : 4) with 10 mm nominal size stone aggregates shall then be laid over the polymer modified cementitious coating before laying the raft.

Truck hopper and its gratings shall be designed for movement of front end loader/ bulldozer over them. Bull dozer weight shall be considered as about 35T. The gratings shall be built of min. 200x28mm thick flats in main direction and min.100mm x 20mm thick in secondary direction. No painting/galvanization shall be provided in gratings. However, two coats of Red oxide Primer to be provided immediately after fabrication.

Plinth protection along with drains shall be provided along the Hopper complex. However, 5m wide paving shall also be provided around machinery hatches.

Earth pressure to be considered for design shall be due to earth pressure at rest (Ko) condition only. Earth pressure due to surcharge intensity of Uniformly Distributed Load (U. D. L) of intensity 2 T / Sq. M. shall be considered in the design.

A minimum safety factor of 1.2 against uplift due to ground water shall be ensured during execution and after execution, considering dead weight of the structure to be

0.9 times only, ground water table to be taken at adjoining formation level and soil wedge angle of not more than 15 degrees.

Also, FOS against uplift, to be taken as 1.0, considering the dead wt. of structure and soil resting on side projections if any in the vertical plane. Inclined wedge action of soil shall not be considered in this case.

Wherever, slope of tunnel exceeds 10^{o}, R. C. C. steps shall be provided for the entire width of each walkway.

3.02.00 **Overhead / Ground Conveyor Galleries and Trestles**

Overhead conveyors shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam or single channel section (ISMB or ISMC) or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girders shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans. Roof truss shall be provided at upper node points of latticed girders to form an enclosure. Contractor can also use tubular steel sections for roof truss only of conveyor galleries. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall conform to IS 1161 and rectangular/square steel sections shall conform to IS 4923. The steel structures using tubular sections shall be designed and fabricated as per IS 806 – “Code of Practice for use of steel tubes in general building construction.” and EN 1993-1-8:2005. The maximum span of overhead gallery shall be limited to 25 meters unless higher span is required due to site conditions, which shall be subject to approval of the Engineer. The gallery should as far as possible be erected as a box section keeping all the vertical and horizontal bracing tied in proper position. The gallery should be checked for all erection stresses that are likely to develop during handling and erection and if required, temporary strengthening of gallery members during erection shall be made.

Seal plates under the conveyor galleries shall be provided in such a way that complete gallery bottom shall form a leak proof floor.

The ground conveyors shall be located in suitably enclosed gallery of structural steel consisting of rigid portal frames spaced at regular intervals and suitably braced. Plinth protection along with drains shall be routed along the ground conveyors.

For double stream conveyor gallery, two side and one central walkway of width 800 mm and 1100 mm respectively shall be provided. The width of two side walkways for single stream conveyor gallery shall be 800 mm and 1100 mm respectively. Both sides of central and side walkways shall be provided with pipe handrails all along the conveyor gallery. Hand railing should not be supported on conveyor supporting stringers. The walkways shall be chequered plate construction with anti - skid arrangement. The anti - skid arrangement will consist of welding of 10 mm square steel bars at a maximum spacing of 500 mm along the length of the gallery. Where the slope of walkway is more than 10^{o}, chequered plate steps with nosing and toe guard shall be provided. The floor of conveyor gallery all along the gallery length, shall be provided with minimum 12 gauge thick seal plates and other drainage arrangements as specified elsewhere

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Conveyor gallery shall have permanently colour coated steel sheet covers on roof and both sides. However in roof, a panel of minimum 1.5 m x 1.5 m area at about 6.0 m center shall be provided with translucent sheets of polycarbonate material for natural lighting. A continuous slit opening of 500 mm shall be provided on both sides just below the roof sheeting. Adequate provision of windows shall be kept on both sides of conveyor gallery as appended in Mechanical Section (Belt conveyor system). Windows shall be provided with wire mesh as specified elsewhere in this specification.

Cross - over with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 100 M intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

For railway tracks passing below overhead conveyor gallery and along conveyors, the railway clearances both underground as well as over ground shall have to be adhered to for design, execution and erection of foundations, trestles, galleries etc., so that movement of locomotives and wagons is not hampered in any way during execution and afterwards. However at the location where the overhead conveyor gallery crosses road / rail line, minimum clearance of 8.0m above the road crest / rail top shall be provided.

For calculation of material load on moving conveyor, a multiplication factor 1.6 shall be used to take care of inertia force, casual over burden and impact factor etc.

Thus material load per unit length of each moving conveyor shall be

$$1.6 \times \frac{\text{Rated capacity of conveyor system}}{\text{Conveyor Belt Speed}} \times F$$

Where, F = 1700/1400 for lime & 1250/900 for gypsum

It should be noted that for structural design, unit weight of lime shall be assumed as 1700 Kgs. / Cu. M. instead of 1400 Kgs. / Cu. M., unit weight of gypsum shall be assumed as 1250 Kgs. / Cu. M. instead of 900 Kgs. / Cu. M. considered for system sizing purpose. Conveyor Gallery structure shall be designed considering both conveyors operating simultaneously.

Conveyor gallery and supporting trestles located between transfer houses / buildings shall be arranged in any one of the following ways.

a) All gallery supporting trestles shall be four legged type only. One end of each gallery span shall be hinged to the supporting trestle and the other end shall

be slide type. Slide type support shall be with P. T. F. E. bearings to allow both rotation & longitudinal movements.

b) In between transfer houses / buildings, four legged trestles shall be placed at a maximum interval of 90 metres. The arrangement shall be such so as to ensure that force in the longitudinal direction (i. e. along the conveyor length) of conveyor gallery of length not more than 90 m is transferred to any four legged trestle. In the space between each successive four legged trestles, two legged trestles shall be provided at regular intervals. The end supports resting on the four-legged trestle can have either ends hinged or one hinge and the other on slide type depending on the arrangements. Slide type support shall be with P. T. F. E. bearings to allow both rotation & longitudinal movements.

End of conveyor gallery which will be supported over transfer house, shall be so detailed that only vertical reaction is transferred from conveyor gallery and no horizontal force in longitudinal direction is transferred from conveyor gallery to transfer house structure and vice - versa.

For trestles and trestle foundations for conveyor galleries located adjacent to existing structures, over ground and under ground facilities, location and details of these trestles and foundations shall have to be decided such that there is no interference both underground as well as over ground with existing structures and facilities. Trestle columns / ground conveyor portal column base shall be kept 300 mm higher than the existing ground level.

3.03.00 **Transfer Houses**

The over ground portion of the transfer house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding (from lowest working floor level till top) and R. C. C. floors comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. However, the lower portion of side cladding, at ground, for a minimum height of 0.9 m above the finished floor level shall be one brick thick wall plastered on both side. In some areas like MCC floors etc., one brick thick wall cladding shall be provided. Brick wall cladding shall be supported on encased wall beams and suitably anchored to adjoining columns and beams. Contractor shall have option to use tubular steel sections for roof truss only. Vertical bracings shall be provided only on four sides along the periphery. Grade slab with 0.9m height one brick thick wall plastered on both side at periphery shall be provided for all transfer houses.

Adequate steel doors and windows for proper natural lighting and ventilation shall be provided. In addition to steel windows, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting.

The roof of Transfer points shall be provided with pre-fabricated insulated metal sandwich panels. Composition of Insulated Metal Sandwich Panels shall be as described elsewhere in the Technical Specification. Adequate slope shall be provided for quick drainage of rain water.

3.04.00 Crusher House

The crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding, at ground, for a height of minimum 0.9m above the finished floor level shall be of one brick thick wall plastered on both faces. Floors shall be of R. C. C. slab over profiled metal deck sheets (to be used as permanent shuttering) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. Within this building cubicles are to be provided for resting room of operators and these shall be constructed with one brick thick brickwork having both sides plastered and roof slab. Adequate steel doors and windows for natural lighting and ventilation shall be provided. Contractor shall have option to use tubular steel sections for roof truss only . Vertical bracings shall be provided only on four sides along the periphery.

The roof of Crusher house shall be provided with pre-fabricated insulated metal sandwich panels. Composition of Insulated Metal Sandwich Panels shall be as described elsewhere in the Technical Specification. Adequate slope shall be provided for quick drainage of rain water.

Crushers shall be supported on R. C. C. deck, which in turn will rest on suitable vibration isolation system consisting of springs and dampers. This R. C. C. deck shall be isolated from the floor. However, the vibration isolation system consisting of springs and dampers may rest on main building framework. Detailed specification of vibration isolation system including the unbalanced force, frequency and amplitude criteria and other design requirements are appended elsewhere in this specification

3.05.00 Control building, M. C. C. Buildings

These shall be steel or RCC framed building with R. C. C. roof and floor. For steel framed building roof /floor shall comprise of RCC slab over profiled metal deck sheets (to be used as permanent shuttering only) over structural beams. Cladding shall be of brickwork/concrete blockwork with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the Technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

All air - conditioned areas, shall be provided with the suspended permanently colour coated aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

3.06.00 Pent House

These shall be of R. C. C. framed structures with columns, beams, slabs and foundations etc. Cladding shall be of brickwork with plastering on both sides. Roof

shall be provided with roof water proofing treatment as specified elsewhere. Adequate nos. of steel doors and windows shall be provided for natural lighting and ventilation.

3.07.00 Gypsum Storage Shed

The Gypsum storage shed shall be RCC framed structure with structural steel work shed with permanently colour coated profiled steel sheet roof and side cladding, grade slab and RCC foundations etc. Roof shall be provided with troughed profile permanently colour coated sheet with adequate slope for quick drainage of rain water.

3.08.00 Toilets

Toilet with potable water line facilities shall be provided in each of the following locations:

(a.) In all M. C. C. Rooms

(b.) Control Building

3.09.00 Staircases, Gratings, Handrails

All floors of transfer points/crusher houses and other facility buildings shall be accessible through staircase. All staircases of Transfer points and crusher house shall be of steel. Cage ladders (min. 450mm wide) shall be provided for access to roof of penthouses, single storey mcc rooms & mumty. All Stairs shall be minimum 1200 mm wide, maximum rise should not be more than 180 mm and minimum tread with 250 mm. Numbers and arrangement (including enclosures etc.) of stair cases shall be such as to meet the fire safety requirement as per guide lines of statutory regulatory bodies. For steel staircases , Stringers shall be of rolled steel channel (minimum ISMC 250) and tread shall be of steel gratings. Out side stairs to transfer points/crusher house shall be open type. Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection for treads of stairs in underground TP's

All gratings shall be electro forged types. Minimum thickness of the grating shall be 40 mm for indoor installation and 32 mm for outdoor installation. However, at entry or road crossing point's minimum thickness of grating shall be 40 mm The opening size shall not be more than 30mmx100mm. The minimum thickness of the main bearing bar shall be 6 mm or as per design requirement whichever is higher. All gratings shall be designed for minimum imposed load of 500Kgs. / Sq. M. If actual expected load is more than the specified load, then actual load is to be considered. All gratings shall be hot dip galvanized at the rate of 610 g. per sq.m. after surface preparation by means of blast cleaning/ acid pickling.

Minimum 1000 mm high hand railing shall be provided around all openings, projections / balconies, walkways, platforms, Stairs, etc. All handrails and ladder Pipes shall be 32 mm nominal bore MS Pipes (medium class) as per IS:1161. Handrails shall have top and middle rails at a height of 1000 mm and 500 mm and the vertical post spacing shall not exceed 1.50 M, with provision of kick Plates (100 mm high and 6 mm thick). All handrails and ladders shall be galvanised at the rate of 610 Gms / Sq. M as per IS:4736.

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3.10.00	**Trenches** All trenches for cables or any other underground facility as detailed out elsewhere shall be of R. C. C. Cable trenches shall be provided with pre - cast R. C. C. covers / chequered plate cover. Cable trenches as well as pre - cast covers shall be provided with edge protection angles and lifting hooks. All embedments / block outs as required and specified elsewhere in these specifications shall be provided. Proper drainage arrangement shall be provided. Trench pre - cast cover weight shall not be more than 65 Kgs. Trench covers near entry or at road crossings shall be designed for 10 T wheel load at centre. Pre - cast covers shall be designed for central point load of 75 Kgs. R. C. C. cable trenches shall be filled with sand after erection of cables, up to top level and covered with pre - cast R. C. C. covers. For cable trenches outside buildings, top level shall be 200 mm above G. L and sand filling shall be overlaid with 50 thk. PCC. Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection all around cut outs / openings in floor slabs, edges of drains supporting grating/precast RCC covers, edges of R. C. C. trenches supporting pre - cast covers, supported edges of pre - cast cover
3.11.00	**Cable gallery/trestles** Cable galleries/trestles shall be made of structural steel. The contractor can use either rolled sections or tubular steel sections. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall conform to IS:1161 and rectangular/square steel sections shall confirm to IS:4923. The steel structures using tubular sections shall be designed and fabricated as per IS:806 – "Code of Practice for use of steel tubes in general building construction." and **EN 1993-1-8:2005**.
3.12.00	**Transformer Foundation**
3.12.01	Foundations of transformers shall be designed for seismic and wind loads in addition to other applicable loads. Block foundations shall be provided for the main transformer block. The oil soak pit, if provided, shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer/reactor along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection tank is provided for the transformer/reactor, oil soak pit of volume equivalent to one-third (1/3) the oil volume of transformer/reactor shall be provided around transformer/reactor. The oil collection tank, in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit. Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/ reactor foundations.

RCC Firewall shall also be provided between the transformers wherever required.

300 mm thick PCC M20 encasement all around the Pylon supports inside soak pit for fire fighting system shall be provided up to top of gravel filling. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

3.12.02 Fencing

Fencing with toe wall and steel gates shall be provided around the transformers. Fencing shall comprise of PVC coated GI chain link fencing of minimum 8G (including PVC coating) of mesh size 75 mm and of height 2.4 m above the toe wall. The diameter of the steel wire for chain link fence (excluding PVC coating) shall not be less than 12G. Fence posts shall be of pre – cast R. C. C. of minimum M20 grade. All corner posts will have two stay posts and every tenth post will have transverse stay post. Suitable R. C. C. foundation for the post and stays shall be provided based on prevailing soil conditions. Gates shall be sturdy with locking provisions.

Toe walls of brick masonry shall be provided between fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200 mm above the formation level with 50 mm thick P. C. C. coping (1: 1. 5: 3) and shall extend minimum 300 mm below the formation level. Toe wall shall be plastered on both sides and painted with two coats of cement paint of approved colour and shade. Toe wall shall be provided with weep holes at suitable spacing

3.13.00 Booster Fan Foundation

Booster Fan foundations shall be RCC block foundation directly resting on virgin soil/ pile below Ground level. The vertical faces of this block foundation shall be isolated from adjacent footings by providing minimum 100mm thick polystyrene board of type-1 conforming to IS: 4671 with density 20 Kg/cum sandwiched between the vertical face of block foundation and 230 thick brick wall all round.

3.14.00 CHIMNEY

3.14.01 Salient Features

Single-flue or multi-flue chimney(s) shall be provided. Chimney shall be of reinforced concrete construction. There shall be one flue (liner) for each unit. The flue gas emission point shall be minimum 150 meters above the plant grade level.

The chimney shell (windshield) shall be constructed using slip form shuttering. Internal platforms of steel structure shall be provided for enabling access to various elevations of the chimney and to provide support to the flue liners. Spacing of internal platforms shall not exceed 45.0 M. The platform beams shall be supported on concrete shell using suitable load bearing arrangement in the recesses provided for the purpose. The platform beams getting supported in the chimney shell shall have complete bearing support within the thickness of shell at that location and shall in no case be supported completely/partially on corbels/ brackets from the shell. "Through openings" in shell if provided to facilitate erection of platform beams shall be closed with cast-in-situ RCC closure wall on the external face of the shell. Necessary dowel bars shall be provided in the shell during construction for this purpose. Openings in the concrete shell for flue duct entry, access door & truck entry door at ground level,

air ventilation etc shall be provided. Hand railing shall be provided all around internal staircase & around the ventilation voids in the internal platform using min. 32 mm nominal bore MS pipes of medium class conforming to IS:1161. Spacing of railing posts shall not be more than 1500 mm centre to centre with a minimum height of 1200 mm. The handrail shall have three rows of horizontal members between the railing posts including the top member. Kick plate of min. size 100x6 thick shall be provided in the hand railing.

The flue duct outside the chimney shall be suitably connected to the flue liner inside the chimney through a transition duct. The transition duct shall be bottom supported and shall be profiled into a circular shape to connect to the flue liner. The flue duct shall be so designed that no load is transferred on the chimney shell due to the duct. The interface between the flue liner and the transition ducting shall be provided with non-metallic fluroelastomeric fabric expansion joint.

The expansion joint in the flue liner shall comprise of non-metallic fluoroelastomeric material suitable to withstand a temperature of 300 Deg C, shall be acid resistant to withstand acidic flue gas condensates arising out of flue gas parameters & operating conditions as specified elsewhere in the specification and shall also prevent dust accumulation. The space between the expansion joint material and the liner shall be packed and sealed by providing a bolster made up of light weight compressible material suitable to withstand a temperature of 300 Deg C and acid resistant to withstand acidic flue gas condensates arising out of flue gas parameters & operating conditions as specified elsewhere in the specification. The bolster shall be confined in texturized glass fabric having a final covering of stainless steel wire mesh.

Chimney roof shall be of RCC slab over a grid of structural steel beams and provided with rainwater drainage system. An internal structural steel staircase supported from chimney shell with chequered plate floor panels and pipe handrails, shall be provided for full height of the chimney and an internal cage ladder for a small height, over last staircase landing to access the chimney roof through a roof access hatch.

The other components of the chimney include liner test ports (for continuous pollution monitoring), liner hatches, grade level slab of RCC with metallic hardener floor finish, acid resistant treatment on roof slab, a large electrically operated grill type roll-up door and personnel access metallic door at grade level, roof drain basin, rain water down comer pipe (150 mm diameter galvanized pipe), connection to plant drains, louvers with bird screens for ventilation and all other openings in the wind shield, mild steel wind strakes (if required), all finishing works, electrical power distribution boards, lighting panels, power & control cabling and wiring systems, stair and platforms lighting, socket outlet, lightning protection and grounding system, aviation obstruction lighting with photoelectric controller etc, communication system, a rack and pinion elevator and other items, though not specifically mentioned but reasonably implied and necessary to complete the job in all respects.

Aviation Warning Lights (AWL) shall be mounted on door panel of required size (open able from interior of chimney shell) fixed to openings in the chimney shell at locations and levels specified elsewhere. Suitable provision for approach to the AWL shall be provided at the platform level. AWL shall be located at about 1-1.5 metre above the top of platform to enable easy handling for maintenance.

The size of roll-up door shall be determined based on minimum requirement for ventilation and transportation & erection of flue segments.

CLAUSE NO.	TECHNICAL REQUIREMENTS
3.14.02	**Design Concept** Design and construction of various components and systems of the chimney shall be in accordance with relevant Indian Standard and where provisions are not covered in Indian Standard, reference shall be made to ACI, BS, CICIND and other international standards. In case of any conflict between this document and the Indian and International Standards, the stipulations of this document shall prevail. Imposed loading for design of all chimney components shall not be less than 5 kN/ Sq.m. An additional 25% of liner load shall be taken as impact loading for liner erection in addition to the liner load. The min. thickness of web for plate girders shall be kept as 12 mm. Seismic forces on the chimney system shall be determined based on site specific seismic information provided elsewhere in this document. Wind forces on the chimney system shall be determined based on site specific wind design criteria provided elsewhere in this document. The chimney and its components shall be designed to resist the most onerous forces resulting from all the possible combinations of the various loadings. Design of all chimney components shall be based on working stress method.
3.14.03	**Wind Shield** The wind shield shall be designed for vertical loading, cross wind loading, seismic loading, circumferential wind loading, thermal gradients etc. The load calculation and load combinations shall be as detailed in IS 4998 (Part 1) : 1992. The wind shield shall be analysed for cases with and without flue liner loads. Forces/stresses in the wind shield due to eccentricity effects of local (e.g. corbel) loadings, insolations effects, rotation of chimney foundations, construction tolerances and moments of second order shall also be considered. Seismic response of the chimney shall be computed by the response spectrum method. At least, the first five modes of vibrations shall be used for this analysis. The cross wind analysis of the chimney shall be carried out irrespective of the value of the Scruton Number for the chimney and other empirical considerations which suggest structural immunity to cross wind oscillations. The effect of the openings/cut-outs in the chimney shell shall be duly considered in the design of the windshield. The minimum thickness of shell shall not be less than 500mm. The stresses for the shell design shall not exceed the limits given in Cl. 7.0 of IS:4998 (PART-I) 1975 for various combinations of loads, excepting the stress in concrete for the case of dead load + wind load which shall not exceed 0.30fck where fck is the characteristic compressive strength of concrete. The minimum vertical reinforcement shall be 0.3% of the concrete area. The maximum spacing of the reinforcement bars shall not be more than 250 mm on each face. The minimum circumferential reinforcement shall be 0.2% of the concrete area. The maximum spacing of the reinforcement bars shall not be more than 200 mm on each face. The circumferential reinforcement in the top 3 meters of the windshield

shall be twice that required from design forces. The clear cover to reinforcement shall be 50 mm.

There shall be a continuous ring of concrete shell without any opening for a height of atleast 5m below the soffit of flue duct openings.

There shall not be any reverse (outward) slope in the inside face of chimney shell. Where there is a sudden change in slope/ profile of the shell, the circumferential reinforcement shall be increased to twice the requirement as per the design in a circumferential band extending atleast 3m above and below such slope/profile change level.

The diameter of the reinforcing bar for the main vertical reinforcement of shell shall not be less than 25mm for a shell height upto the top level of flue duct opening.

Shell thickness between any two 10m reference levels shall not vary more than 150mm.

The minimum thickness of shell/closure wall at beam support recess/ opening locations shall be 100mm.

Grade of concrete for chimney shell, and other super structure shall be minimum M 30. Only OPC cement shall be used for Chimney shell and other super structure.

The final design shall be checked & verified by 'Wind Tunnel Test' and shall be conducted at a reputed institution. Dynamic interference effects due to additional chimney(s)/NDCTS's and other tall structures located in the area or in the future expansion stage of the project shall be determined along with the other topographical features of the local area through model test.

3.14.04 **Flue Liners**

The flue gas parameters & various operating conditions for selection of flue liner material, material specification for flue liner and the criteria of flue gas exit velocity for sizing the flue liner shall be as specified elsewhere in the specification.

For flue liner with base metal as mild steel, the thickness of the base metal shall be determined from structural considerations. The thickness of any clad metal/coating/block lining etc. provided on the base metal shall not be considered for computing the structural strength of flue liner. The minimum thickness of the mild steel base metal shall, however, not be less than that specified elsewhere in the specification.

Two manholes placed diametrically opposite shall also be provided in each flue at all internal platform levels.

The supporting/restraining arrangements of the liners should be such that expansion of the liners longitudinally or circumferentially is not restrained.

Clean-out door shall be provided below the flue for the removal of ash.

3.14.05 **Internal Platforms**

The platforms shall be designed for dead, imposed (live), erection work and other possible loadings and temperatures effects. These platforms shall provide support and lateral restraint to the steel liners and provide access for inspections and maintenance. Forces imposed on the floors due to lateral restraint of flues shall be enhanced aptly for impact effects. These platforms shall also be designed suitably for

the liner erection works. The platform shall be made up of chequered floor panels supported on grid of structural steel beams. All beams shall have bolted connections. The maximum permissible deflection in main steel girders supporting flue liner shall be span/1000.

3.14.06 Internal Staircase

The staircase shall have a clear passage way width of not less than 800 mm and a clear headroom of not less than 2100 mm. The riser height shall not be more than 175 mm and tread width shall not be less than 225 mm.

3.14.07 Foundation

The chimney foundation shall be designed for the most critical combination of forces and moments, resulting from all possible combinations of the various loadings from the chimney system during all stages of constructions. The effect of water table shall be considered and the foundation shall be checked for overturning for minimum and maximum vertical loads. There should be no uplift under any portion of the foundation for any loading condition. Since chimney is a wind sensitive structure no allowance shall be made in the load carrying capacity of the bearing strata / piles under any load case/combination with wind. No allowance shall be made in the stresses for design of foundation for wind loading. The foundation diameter to depth ratio shall be maintained to around 10 and should preferably not exceed 12. The diameter of the reinforcing bar for the main radial and tangential reinforcement for the foundation shall not be less than 25mm. The spacing of radial steel at the outer edge of the foundation shall not be more than 250mm. Grade of concrete for foundation shall be minimum M 25.

3.14.08 Thermal insulation

The insulation shall be semi-rigid, resin bonded type, in the form of slabs and shall conform to IS: 8183. Blanket type insulation shall not be used. The density of insulation shall not be less than 64 kg/cu.m for resin bonded glass wool insulation and 100 kg/cu.m for resin bonded rock wool. The coefficient of thermal conductivity of insulation shall not be more than 0.52mW/cm/oC at a mean temperature of 100oC.

The insulation thickness shall be determined based on the maximum/minimum ambient temperature, surface air velocity worked out based on the draught of ventilation air in the annular space between the flue liner and chimney shell, insulation surface emissivity of 0.3 and the insulation cold face maximum temperature not exceeding 55 degree Celsius. The draught of air in the annular space shall be the natural draught created by the heating of air by the flue liner and the air being vented out through the openings in the chimney shell. The increase in the annulus air temperature due to the rising heated air shall be taken into account while calculating the insulation thickness.

The insulation thickness shall not be less than 100 mm, in any case, and shall be provided in two layers with the second layer of insulation covering the joints of the first layer. The insulation shall be wrapped on the outer-most surface with galvanised wire mesh using MS galvanised pins and speed washer.

3.14.09 **Chimney Painting**

(i) All exposed steel surfaces (including exterior surface of mild steel flue liner in case the design does not envisage provision of thermal insulation on the exterior surface of flue liner) except surfaces of steel wind strakes shall be painted as specified in corrosion protection clause of this specification.

(ii) All exposed surfaces of steel wind strakes shall be painted with epoxy phenolic coating system having total 240 microns DFT.

a) All steel surfaces shall be provided with two component epoxy primer coat (having solid by volume minimum 51% ±2%) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique.

b) Primer coat shall be followed with the application of Intermediate coat of epoxy phenolic coating (solid by volume minimum 63%) of minimum 100 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.

c) Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied in shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.

(iii) All steel parts embedded in concrete like Strake embedment assembly including bolts, nuts, washers, pipe sleeves and insert plate shall be galvanized as per IS:4736. The minimum weight for galvanizing shall be 610 g/sq.m and shall comply with relevant IS Codes.

(iv) The inside surface of chimney shell above roof, horizontal surface of shell at top, underside of concrete roof slab, external surface of mini-shell above roof etc shall be painted with epoxy phenolic coating system having total 220 microns DFT.

a) All concrete surfaces shall be provided with two component transparent polyamide cured epoxy sealer coating (having solid by volume minimum 40% ±2%) of minimum 50 micron DFT to be applied over cleaned surface in multiple coats. Surface to be coated shall be absolutely dry, clean and dust free.

b) Sealer coat shall be followed with the application of Intermediate coat of epoxy phenolic coating (solid by volume minimum 63%) of minimum 100 micron DFT. This coat shall be applied after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.

c) Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours

exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.

d) The entire external surface of chimney shell shall be painted with epoxy phenolic coating as specified in (iv) above in alternate bands of 'signal red' and 'bright white' colours.

3.14.10 Electrical System

415V, normal and emergency AC power supply for chimney shall be derived from main plant power supply system. Emergency supply shall feed 20% of platform lighting, 50% of staircase lighting, aviation obstruction lighting and elevator load. All other loads shall be connected on normal power supply.

Ambient temperature for design of all equipment shall be considered as 55 deg. C which is likely to be encountered inside the chimney. The equipment shall be suitable for installation and render trouble free operation at higher ambient temperature and rigorous weather conditions prevailing at chimney.

All equipment supplied shall comply with relevant IS Standards.

The distribution boards of chimney shall comprise switch fuse units of appropriate ratings. Emergency board shall have two incomers, one from emergency supply and other from normal AC distribution board itself. Auto changeover scheme shall be provided in emergency board to enable changeover to healthy source on failure of any source.

Dry type isolating transformer of Dyn connection shall be provided in emergency board to obtain neutral lead, in case 3 phase 3 wire emergency supply is derived from main plant.

Various platforms shall be illuminated by dust tight HPSV well glass lighting fixtures. Average illuminations level of 150 lux shall be maintained on equipment and 70 lux on platforms & 100 lux on staircases (minimum 1 lighting fixture at each landing).Any additional fixture to take care of dark patches/shadows shall also be provided. Lighting system shall be controlled through MCB provided in lighting panel.

A lighting and power panel each shall be located at grade level and at other in between levels as required. All distribution boards, aviation lighting controls, etc. shall be located at grade level only. At each platform, 1 No. 63A, 415V welding receptacle and 1 No. 20A, 240V receptacle shall be provided and shall be fed from power panel. Wiring installation for lighting fixture shall be of PVC insulated copper/aluminium wires through galvanised steel conduits.

Aviation obstruction lighting system shall conform to the requirements of the latest rules and regulations of the International Civil Aviation Organization (ICAO), National Airports Authority (NAA) and Directorate of Air Routes and Aerodromes (DARA). The type of aviation obstruction lighting system shall be of medium intensity aviation obstruction lights having an effective intensity of 2000 to 20,000 cd depending upon back ground illuminance. Obstacle lights shall have a day time effective intensity of minimum 20000 cd. The intensity of lights shall be 20000 cd ± 25% at twilight and shall reduce automatically to a night time intensity of 2000 cd ± 25% through the use of photo-cell. The obstacle lights shall flash simultaneously at a rate between 20 to 60 per minute. A minimum of three levels will be provided with aviation obstruction

lights and there will be four light units per level. The lowest level should not be lower than 45 meters above the ground and vertical spacing of the intermediate levels could vary between 45 and 105 meters. The intermediate lights shall be spaced as equally as possible. Aviation obstruction lighting shall be complete with lights, photo cell, controller, special cables, etc..

A temporary aviation obstruction lighting system shall be provided during construction of the chimney.

Cables from distribution board to lighting panels/power panels/receptacles shall be 1100V grade, multicore FRLS HR-PVC insulated, PVC inner sheathed, armoured, PVC outer sheathed stranded copper/ Aluminuim laid on galvanised sheet steel cable trays. Cables shall be terminated using double compression type cable glands and solder less crimping type tinned copper cable lugs. Minimum size of the power cable shall not be less than 2.5 sq.mm copper or 4 sq.mm Aluminuim. Minimum size of control cable shall not be less than 1.5 sq.mm.

Lightning protection system shall comprise minimum 3 vertical air terminations for each flue liner, horizontal air terminations and minimum 4 Nos. of down conductors spaced 90 degrees apart routed all along chimney height on external surface and connected to the earthing system. Down conductors shall be of minimum 50x6 mm galvanized steel strip. Each down conductor shall be provided with a test link at 1 metre above ground level. Each test link shall be enclosed in a galvanised sheet steel enclosure. Above ground level earthing and lightning protection system shall comprise galvanised steel strips. These materials provided at top 12 meters shall have additional coating of 2 mm thick seamless lead cover and the accessories like nuts, bolts, washers etc. shall be of stainless steel to take care of corrosion. Chimney earthing system shall be interconnected to main plant earthing system.

A temporary lightning protection & earthing system shall be provided during construction of the chimney till a permanent lightning protection & earthing system is installed. In no case reinforcement bars of Shell should be used as earthing Down Conductors

Communication system comprising of telephone socket at every internal platform level and at grade level, necessary wiring installation, a telephone hand set, junction boxes etc. shall also be provided. Telephone cables shall be of minimum 0.6 mm diameter annealed high conductivity electro copper conductor, PVC insulated, twisted, PVC tape wrapped, screened, rip corded, PVC sheathed, conforming to relevant ITD (Indian Telephones Department) specifications.

All equipment to be supplied shall be of type tested quality. The Contractor shall submit for Owner's approval the reports of all type tests as listed below:

(A) Distribution boards/panels-Degree of protection tests

(B) Aviation lights:

(1) Intensity Test

(2) Degree of protection test

For various equipment, the technical requirements and practices shall conform to the relevant clauses of the main plant electrical specification.

3.14.11 **Rack and Pinion Elevator**

A rack and pinion elevator, with a load carrying capacity of 400 kg (min) (passenger cum goods), cabin floor size of 1100 mm x 1000 mm (min.) and an operating speed

of 40 m/min. (approx.), shall be provided for travel from the grade level to the top of the chimney. A landing platform shall be provided at all access/ platform levels. The elevator shall be of a proven and approved make. Enclosure shall be fabricated from tubular steel and expanded metal or wire mesh, 2.1 m high (Approx.). A Safety device comprising of an over speed governor in constant mesh with the rack by means of a flame hardened steel pinion shall be provided to protect the cab against over speed during the cab downward motion and the same shall actuate the brake mechanism and stop the down ward motion gradually. The lift shall be installed using anchor fasteners. The electrical requirement of the system shall conform to the main electrical specification. Drive motor shall be of S3 duty class with CDF of 25% and maximum number of 120 starts per hour in 55 degree Celsius ambient temperature. The motor shall be provided with internal 220V AC single phase space heaters or an alternate heating system. The elevator shall be supplied, installed, painted, tested, commissioned etc. complete with all mandatory spares (as specified in Part-F of this specification) and operation maintenance manual

4.00.00 **Drainage & Water Supply Works**

4.01.00 Drainage System:

The drainage arrangements shall be so planned so as to ensure quick disposal of drainage water without stagnation and / or overflow. It is envisaged to clean the facility buildings etc. with water periodically.

Minimum 4 nos. down comers shall be provided in each building at corners.

For Conveyors, each down comer shall lead the water / slurry to pit (of 2 Cu.M capacity) to allow settling of lime/gypsum. The water from the pit shall overflow into contractor's R.C.C drain, which will lead the discharge finally into owner's drain routed alongside the nearby road.

For Ball Mill building, Gypsum dewatering building, FGD control room building, peripheral drains (Brick drains with steel gratings provided around the building) shall lead the water / slurry to a local pit (of 2 Cu. M. capacity) near each facility to allow settling. The water from the pit shall overflow into contractor's R.C.C drain, and finally into owner's drain routed alongside the nearby road.

In case of Control rooms and M. C. C. buildings Pump houses, etc, water / slurry coming from down comers shall discharge into peripheral drains (Brick drains with steel gratings provided around the building) which will lead the water / slurry into contractor's R.C.C drain, which will lead the discharge finally into owner's drain routed alongside the nearby road.

Contractor's scope shall also include construction of necessary culverts under the rail lines / roads as per railway / I. R. C. standards and approval of Railway culverts from concern Railway authorities.

4.02.00 **Internal and external water supply, drainage etc.**

The scope for potable water supply includes all distribution systems, tanks, pipes, fittings etc. as required and as described here or elsewhere in the specifications.

The scope for service water supply and dust control water supply shall be as described elsewhere in the specifications.

For water supply, medium class galvanized mild steel pipes conforming to IS: 1239 shall be used.

All facility buildings shall be provided with open surface brick drains of minimum size of 300 mm width and 300 mm depth all around the periphery. All drains excepting the peripheral drains around facility building shall be of R. C. C. construction. Drains shall have removable steel grating cover and shall be provided with edge protection angles.

The scope for foul water from toilets shall include layout and laying of sewers up to the Employer's main sewer line for sewerage system together with all fittings and fixtures and inclusive of ancillary works such as connections, manholes and inspection chambers within the building and from the building to the Employer's sewer line.

For rain water down comer and those to be used for conveying water / slurry generated from cleaning of buildings floors, Galvanised MS pipes conforming to IS: 1239 (for 150 mm NB Medium grade pipes) with welded joints shall be used for MCC buildings, penthouse, control rooms, ball mill building, gypsum dewatering building, storage sheds.

Galvanising shall be as per IS: 4736. The minimum mass of zinc coating shall not be less than 400 gms/sq.m. as per IS:6745. The zinc coating shall be smooth and shall be subjected to testing as per IS: 2633, for uniformity of coating. The zinc coating shall be free from all defects as per IS: 2629.

All rain water down comers shall be provided with roof drain heads and complete with shoes bends, junctions, sockets, adapters, brackets and finished with anti corrosive painting over a coat or primer.

For design of building drainage system IS: 1742 shall be followed.

For sanitary / sewerage pipes above ground, sand cast iron pipes conforming to IS : 1729 with leak proof lead joints.

For underground drain pipes, minimum class NP - 2 pipes conforming to IS: 458. At road crossings, concrete pipes of class NP 3 conforming to IS: 458 and at rail crossing R.C.C. box culvert to be provided.

For sewerage below ground stoneware pipes conforming to IS: 651 with concrete bedding and haunch.

5.00.00 COLOUR COATED AND OTHER SHEETING WORK

5.01.00 Material

a) Wall Cladding & Roofing Material

Troughed permanently colour coated sheet of approved shade and colour shall be

i) either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

ii) or of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

iii) or of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

Alternatively aluminium feed material of minimum bare metal thickness of 0.7 mm of aluminium alloy of Series 31000 and above as per IS: 737 and IS: 1254.

b) Metal Deck Roof Material

Troughed permanently colour coated metal decking sheets shall be

i) either of steel with minimum 0.8mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275

ii) or of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275

iii) or of steel of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275.

Alternatively aluminium feed material of minimum bare metal thickness of 0.9 mm of aluminium alloy of Series 31000 and above as per IS: 737 and IS: 1254 can also be used for metal decking.

Thickness tolerance of (+/-) 0.04mm is permissible. However, all design calculations shall be carried out on the basis of lowest value of sheet thickness provided.

5.02.00 Colour Coating

Steel shall be colour coated with total coating thickness of at least 40 microns (nominal) comprising of silicon modified polyester (SMP with silicon content of 30% to 50%) paint or Super Polyester paint, of minimum 20 microns (nominal) dry film thickness (DFT) on external face over primer coat of minimum 5 microns (nominal) and minimum 10 microns (nominal) SMP or super polyester paint over primer coat of minimum 5 microns (nominal) on internal face. SMP and Super polyester paint systems shall be of industrial finish of product type 4 of AS/NZ2728.

5.03.00 Design Criteria

For wall cladding insulated / uninsulated sides and roof, permanently colour coated sheet of troughed profile shall be used. The nominal depth of trough shall be 30 mm.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	For profiled metal decking sheets (to be used for RCC floor slab or roof slab) the sectional modulus and moment of inertia of troughed profile per meter width shall be so as to limit the deflection of sheets to span/250 under total super imposed loading (DL +LL) comprising the self-weight of metal deck sheet, dead weight of green concrete and an additional construction load 100kg per sq.m for two span condition. The section modulus and moment of inertia of troughed profile shall be computed as per the provisions of IS: 801 for satisfying the deflection and strength requirements. For metal deck sheets used for roofing (with or without RCC) and side cladding, the sectional modulus and moment of inertia of troughed profile per metre width shall be such that the deflection of sheets is limited to span/250 under design wind pressure for two span condition. The sectional modulus and moment of inertia of troughed profile shall be computed as per the provisions of IS: 801 for satisfying the deflection and strength requirements. No increase in allowable stress is permissible under wind load condition.
5.04.00	**Fasteners** Side cladding/roofing/decking sheets shall be fixed to the runner/purlins using self-drilling special coated fasteners confirming to corrosion resistant class 3 of AS3566 and tested for 1000 hours salt spray test. Spacing of Self-drilling fasteners in transverse direction (along runners/purlin) shall be equal to the pitch of trough or 250(+/-100) mm, whichever is lesser and in longitudinal direction at every runner/purlin location. Shear anchor studs shall also be provided through troughed permanently colour coated metal decking sheets metal deck, which are to be used as permanent shuttering, at regular interval on all top flange / flange plate of structural beams. The shear anchor studs for fixing metal deck sheet to floor structural beams shall conform to Type-B studs specified in AWS D1.1/D1.1M or equivalent as shear connector of 19mm diameter and 100mm length manufactured from cold drawn round steel bars conforming to the requirement of ASTM A 29, of grade designation 1010 through 1020, of standard quality with either semi-killed or killed, welded by Drawn Arc Stud Welding through metal deck sheet. The shear anchor studs for fixing metal deck sheet to roof structural purlins shall conform to Type-B studs specified in AWS D1.1/D1.1M or equivalent as shear connector of 16mm diameter and 65mm length manufactured from cold drawn round steel bars conforming to the requirement of ASTM A 29, of grade designation 1010 through 1020, of standard quality with either semi-killed or killed, welded by Drawn Arc Stud Welding through metal deck sheet. Alternatively, J/U type hooks shall be used in roofing which shall be provided in transverse direction (along runners/purlin) at a spacing equal to the pitch of trough or 250(+/-100) mm, whichever is lesser and in longitudinal direction at every runner/purlin location.
5.05.00	**Miscellaneous Details** To minimize the number of joints, the length of the sheet shall preferably be not less than 4.5m, cut pieces shall not be used, unless specifically approved by the Engineer. However, the actual length shall be such so as to suit the purlin / runner spacing.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	Lap between the sheets shall be at least 150mm in the longitudinal direction and at least one crest wide in the transverse direction which shall be properly anchored / fixed with fasteners. Z spacers if required shall be made of at least 2 mm thick galvanised steel sheet of grade 350 as per IS: 277 Sealant used for cladding shall be butyl based, two parts poly sulphide or equivalent approved, non stainless material and be flexible enough not to interface with fit of the sheets Filler blocks as a trough filler shall be used to seal cavities formed between the profiled sheet and the support or flashing. The filler blocks shall be manufactured from black synthetic rubber or any other material approved by the Engineer. All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and any weather/moisture sealants with appropriate material and coating specification as mentioned above for the outer face of the metal cladding. Overlap shall be min. 150 mm or as specified by manufacturer.
5.06.00	**Pre-Fabricated Insulated Metal Sandwich Panels** For structures where Pre-Fabricated Insulated Metal Sandwich Panels shall be used for Roofing, the sandwich panels shall comprise top sheet as troughed permanently colour coated sheet & bottom sheet as plain permanently colour coated with 50mm thick insulation sandwiched between the two sheets. Each sheet shall be **i)** either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150 **ii)** or of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150 **iii)** or of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150. Alternatively aluminium feed material of minimum bare metal thickness of 0.7 mm of aluminium alloy of Series 31000 and above as per IS 737 and IS 1254. Metal sheets (steel or aluminium) shall be colour coated with total coating thickness of at least 40 microns (nominal) dry film thickness (DFT) comprising of Silicon Modified Polyester (SMP with silicon content of 30% to 50%) paint or Polyester paint, of minimum 20 microns (nominal) SMP or polyester paint on one side (exposed face), over minimum 5 micron (nominal) primer coat and minimum 10 micron (nominal) SMP or Polyester paint over minimum 5 micron (nominal) primer coat on other side. SMP and Super Polyester paint shall conform to product type 4 of AS/NZS 2728. Troughed sheet shall be of approved profile, sectional properties, (suitable for the specified loading / deflection and purlins / runners spacing), colour and shade.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	Special coated fastener conforming to corrosion resistant Class 3 of AS3566 and tested for 1000 hours salt spray test shall be used for fixing Pre-Fabricated Insulated Metal Sandwich Panels with the structural members below. The contractor shall prepare working drawings of sheeting system including end and side laps, fixing details etc. before starting sheeting work at site.
5.07.00	**Polycarbonate Sheets** The polycarbonate sheet to be used for cladding and glazing purpose in conveyor galleries, Transfer points & pump houses shall have toughed profile to match with the metal cladding profile. Minimum 3.0mm thick fire retardant and UV resistant polycarbonate clean sheet of approved make shall be used. The polycarbonate sheet shall be installed along with the metal cladding so as to have a watertight lapping arrangement. Suitable detailing shall be made to cater for the thermal expansion. IS 14434 to be referred for other details
6.00.00	**Roof Details**
6.01.00	Roof slab shall be minimum 150 mm thick(**above the top surface (crest) of the metal deck sheet**) and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom.
6.02.00	900 mm high and minimum 100 mm thick R. C. C. parapet wall shall be provided over roofs of all buildings. Parapet wall shall have suitable coping. External face of parapet wall of the buildings provided with metal cladding shall also be finished with metal cladding of design and colour as per approved architectural drawings.
6.03.00	Junction of roof and parapet shall be provided with 150 x 150 mm size concrete fillet.
6.04.00	Drain level shall be provided with 45 x 45 cm size khurras having minimum thickness of 30 mm of M-15 concrete over PVC sheet of 1 m x 1m x 400 micron and finished with 12 mm 1 : 3 cement : sand plaster.
6.05.00	Roofs of all control rooms, M. C. C. rooms, penthouse etc., shall have roof water proofing treatment. Roof water proofing treatment shall be as follows: 1) Application of polymerised mastic over the RCC roof to achieve smooth surface as primer coat. 2) Application of high solid content liquid applied urethane based elastomeric water proofing membrane, over the primer coat, to give uniform joint less dry film thickness of minimum 1.5 mm (as per ASTM C 836 and C 898). 3) For efficient disposal of rain water, the run off gradient for the roof shall not be less than 1: 100. This gradient shall be provided by screed concrete M-15 (using 12.5 mm coarse aggregate) and / or cement mortar (1: 4) over the elastomeric water proofing membrane with 25mm thick cement mortar (1:4) topping. 4) Wearing course at top, shall consist of 25 mm thick P. C. C. (M-15) cast in panels of maximum 1.2 x 1.2 m size and reinforced with 0.56 mm diameter galvanized chicken wire mesh and sealing of joints using sealing compound / elastomeric water proofing membrane. Pathways for handling of materials and movement of personnel shall be provided with 22 mm thick chequered cement concrete tiles as per IS : 13801 for a width of 1000 mm in place of P. C. C.
6.06.00	For efficient disposal of rain water, the run off gradient for the roof shall not be less than 1:100. This gradient can be provided either in structure or subsequently by

CLAUSE NO.	TECHNICAL REQUIREMENTS
	screed concrete M-15 (using 12.5 mm coarse aggregate) and/ or cement mortar (1:4). However, minimum 25 mm thick cement mortar (1:4) shall be provided on top to achieve smooth surface.
6.07.00	Medium class galvanised mild steel pipes conforming to IS: 1239/ IS: 3589 with welded joints shall be provided for rain water down comers to drain off rain water from the roof. These shall be suitably concealed with masonry work, to match with the exterior finish. The number and size of down comers shall be governed by IS: 1742 and IS: 2527. RCC roof shall be provided with 45 x 45 cm size Khurras having minimum thickness of 30 mm with M-15 concrete over PVC sheet of 1mx1mx400micron and finished with 12 mm thick cement sand plaster 1:3.
6.08.00	Access to RCC roof of Gypsum dewatering building, FGD Control room building, MCC building, Ball mill building shall be through RCC staircase, and roof access to all other buildings all shall be through cage ladder as per requirement.
6.09.00	Fillets at junction of roof and vertical walls shall be provided with cast - in - situ cement concrete (M-15) nominal mix followed by 12 mm thick 1:4 cement sand plaster.
6.10.00	The rainwater down comers shall be provided with suitable C.I. grating at inlet point.
7.00.00	**RCC Floors, Paving & Grade Slab details** The floor slabs shall be minimum 150 mm thick(above the top surface (crest) of the metal deck sheet) and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom. In case Bidder opts for steel super-structure with RCC floors/ roof, the bidder shall necessarily use Troughed permanently colour coated metal decking sheets having minimum thickness of 0.8mm as permanent shuttering. The detailed material property requirement of metal deck sheet is specified elsewhere in the specification. These profiled metal deck sheets shall be fixed to the structural steel beams/ purlins using headed shear anchor studs specified elsewhere in the specification. Chequered plates (used for floors, walkways etc.) shall be minimum 6 mm thick. Mild steel flats/angles of suitable size shall be welded to the bottom portion of chequered plates at a designed spacing to stiffen chequered plates suitably. Chequered plates shall be fixed by staggered welding of suitable size. Floors of trenches shall have integral finish to concrete base. Toe guard of size 100 x 6 mm shall be provided at various openings provided in floors e.g. around stair case openings, chute openings and other similar cutouts. For conveyor walkways, angle runner to act as toe guard shall be provided. R. C. C. floors (where no brick masonry walls are provided) shall be provided with handrails all along the periphery. RCC paving of minimum 150 mm thick with M25 grade concrete, over an under bed as specified herein shall be provided for areas mentioned below. RCC paving shall be designed as rigid reinforced concrete pavement for the crane/ vehicular/ equipment movement loads which the paving has to bear. The under bed for paving shall consist of preparation and consolidation of sub-grade to the required level, laying of stone soling of 200mm compacted thick for normal duty paving and 400mm

compacted thick for heavy duty paving with 63 mm and down aggregate with interstices filled with selected moorum/ non-expansive soil followed by 75 mm thick 1:4:8 PCC (1 part cement, 4 parts sand and 8 parts stone aggregate) with 40 mm nominal size aggregate. For normal duty paving, reinforcement of the RCC paving shall consist of minimum 8mm dia bars @ 200 mm c / c in both directions at the centre of the slab. For heavy duty paving/ passage, reinforcement of the RCC paving shall consist of minimum 10mm dia bars @ 200 mm c / c in both directions at the centre of the slab.

Paving areas shall be provided with the metallic hardener floor finish as specified elsewhere in the specification.

Passages shall be provided inside the FGD block connecting to the outer periphery road to have access to the various facilities/buildings. These passage areas shall be provided with heavy duty paving for movement of heavy vehicles. The top surface of the passages shall be finished with 50 mm thick metallic hardener topping. Heavy duty paving shall also be provided for the areas in the equipment lay down area, unloading & maintenance area with 50 mm thick metallic hardener topping.

Lightly loaded areas such where no heavy traffic movement is envisaged shall be provided with Normal Duty paving.

All facility buildings shall be provided with 750 mm wide plinth protection all around. It consists of 50 mm thick P.C.C. M-20 grade with 12 mm maximum size aggregate over 200 mm thick stone soling using 40 mm nominal size rammed, consolidated and grouted with fine sand

An area of minimum 5 m width all around the tank foundations and other facility buildings shall be paved. This paving shall be beyond the extent of plinth protection. Further, heavy duty paving shall be provided for passages connecting the outer periphery road to have access to the various facilities/buildings.

Plinth level of all buildings shall be kept at least 500 mm above the finished grade / formation level.

Suitable open RCC drains shall be provided to dispose off storm water drain. The paving shall be provided with slope of 1:500 to dispose the surface water/wash water to the nearest drain.

Sewer lines (Cast Iron), interconnected by sewer manholes (RCC) at regular intervals (not exceeding 30 meter centre to centre) shall be provided to dispose off sewage from FGD block to sewage pump house.

GRADE SLAB OF BUILDINGS AT GROUND FLOOR

In buildings, the grade slab shall consist of 150mm thick RCC M25 grade base slab over an under bed as specified below. The under bed for ground floor slab shall consist of 75mm thick 1:4:8 PCC on stone soling of 200mm compacted thick with 63 mm and down aggregate with interstices filled with well graded selected sand/ moorum/ non-expansive soil on compacted and dressed sub - grade. Reinforcement for the slab shall consist of minimum 8mm dia. bars @ 200 mm c/c at top & bottom of the slab in both directions. However, at unloading & maintenance area, stone soiling of minimum 400mm thick and grade slab with minimum 10mm dia bars @ 200 mm c/c at top and bottom in both directions shall be provided.

Further, top surface of grade slabs shall be finished with 50mm thick metallic hardener topping.

CLAUSE NO.	TECHNICAL REQUIREMENTS
8.00.00	**Brickwork and allied masonry works** All brick walls shall be non - load bearing in-filled panel walls. All brickwork shall be designed as per Indian Standards and shall be plastered on both faces. All external walls shall be minimum one brick thick in 1: 6 cement: sand mortar. Brick walls shall be provided with 12 mm and 18 mm thick 1: 6 cement: sand plaster on smooth and rough face of the brick work respectively. Bricks to be used in brickwork shall be of minimum Class designation 50. Brickwork cladding for various structures shall be so provided that there is a clear gap of 40 mm between inside face of external brick wall and outside face of column flange. Structural steel wall beams supporting brickwork shall be suitably encased with plaster or 1: 2: 4 concrete as the case may be. In case of box type steel beam, encasement shall be done with cement sand plaster in specified thickness and proportions over G. I. wire netting of 0.9 mm thickness. Parapets, chajjas, windows and door heads, architectural faces, fins etc. shall be provided with drip course in 1 : 4 cement sand mortar. 50 mm thick Damp proof course shall be provided at plinth level for all brick wall. All R. C. C. ceilings shall be rendered smooth and finished with whitewash unless otherwise specified. Ceiling of control rooms, M. C. C. rooms (except areas provided with false ceiling) shall be provided with 6 mm thick plaster.
9.00.00	**Earthing Mat** 40 mm Dia MS Rods as earthing mat, placed at a distance of 1.0M away and at depths between 0.60M and 1.00M shall be supplied and laid all around the periphery of buildings, structures, and outdoor equipment, as per the approved drawings. Risers of 40 mm Dia MS Rods and connecting to the above Earthing mat shall also be supplied and laid in position by the Contractor, as per the approved drawings. Risers shall be laid up to a height of 300 mm above the local Ground level, at each of the columns of the buildings on outside of the buildings, and minimum 2 (Two) numbers for structures and outdoor equipment. The contractor also supply and lay necessary number of 3.0 M deep vertical 40 mm Dia MS Rods Earthing electrodes and connecting them to the Earthing mat, as per the approved drawings and the supplying and laying of 40 mm Dia MS Rods for connecting the Contractor's earthing mat with the Employer's earthing mat separately at two locations.
10.00.00	**SITE LEVELLING** Site leveling of gypsum storage area , lime storage area , gypsum dewatering area , truck hopper and associated areas to be levelled in one blocks as defined in the drawing no. 4410-999-POC-F-001 titled, "Layout plan of FGD System ". Each block shall be finished to the formation level as specified in drawing. Bidder shall deploy adequate number of experienced site leveling contracting agency(s) with requisite earth moving and compacting equipment to complete the work as per schedule.

CLAUSE NO.	TECHNICAL REQUIREMENTS

Bidder shall carry out the topographical survey before he commences detailed design and site leveling. This survey shall cover the entire FGD area including gypsum storage ,gypsum handling area , lime storage area ,gypsum dewatering area , truck hopper area, limestone grinding and slurry storage area in Bidder's scope of work. Based on field observations the contractor shall prepare and submit for Owners review the survey maps of the surveyed sited on suitable scale, indicating grid lines, contour lines and demarcating all permanent features like roads, railways, water-ways, buildings, power lines, natural streams, trees etc. For each area two sets of survey maps shall be prepared and submitted, one showing the spot levels and contours with grid lines and the other showing the grid lines, contours and permanent features

Since the construction of roads and drains for the FGD area including gypsum storage ,gypsum handling area , lime storage area ,gypsum dewatering area , truck hopper area, limestone grinding and slurry storage area is included in the scope of Bidder, it shall be the responsibility of the Bidder to ensure that these facilities are also constructed along with site leveling works. Bidder shall ensure that road access and drainage facilities for each block is available when site leveling in that block is completed. Unless otherwise instructed by the Engineers, all roads and drains within a block shall be constructed by the bidder within a month from the date of completion of site leveling of that block.

The specified formation level(s) shall be achieved either by excavation where the existing ground levels are higher than the specified formation level or by raising by controlled filling with borrowed earth where the existing ground levels are lower than the specified level

All materials arising out of site clearance and excavation shall be the property of owner. They shall be dealt with in the manner specified by the Engineer. Earth / boulders / rock etc. excavated and useful portion (serviceable materials) of trees cut shall be stacked at suitable places within Owner's acquired land for the plant including the reservoir and the ash disposal area in a manner as directed by the engineer. Woods, branches, trunks of trees shall be termed as serviceable material. Other materials like twigs, leaves, roots, vegetable and organic matters etc. shall be termed as unserviceable material and shall be sorted out from the serviceable materials before disposal. They shall be cleared from the area and disposed off at places within Owner's acquired land for the plant including the reservoir and the ash disposal area in a manner as directed by the engineer.

If the excavated material is suitable and accepted by the Engineer as fill material, the same can be used for filling in other areas where raising by filling is required. Otherwise the same shall be taken and stacked at places(s) within the plant boundary as directed by the Engineer.

Filling with rock shall be done only after the written permission of the Engineer in the following manner:

Filling with rock shall be done only in areas identified for laydown and preassembly .

Original ground after removal of all organic and vegetable matters shall be consolidated by rolling as directed by the engineer subject to a minimum of six passes of 8-10 tonnes roller.

- Excavated rock shall be laid (on original ground or after filling 300 mm thick layers of soil as specified), in layers not exceeding 1000 mm and rolled with with vibratory roller (10-15 tonnes static weight) with minimum six passes.

- Over the compacted layer of rock, soil shall be filled in horizontal layers not exceeding 300mm in compacted thickness. The soil shall be compacted as specified elsewhere.

- It shall be ensured that the top soil layer is in minimum 3 layers of 300 mm each. To achieve this the thickness and number of rockfill layers below can be suitably adjusted.

Contour map and spot levels of the area based on the preliminary survey carried out by Owner is enclosed for the purpose of guidance of Bidder. Refer tender drawing no. "4410-999-POC-F-001". However, Owner does not lake any responsibility about the accuracy of the survey details furnished and any variation of the said data shall not constitute a valid reason for changing the terms and conditions of the contract. Bidder is requested to carry out his independent assessment of the existing ground levels before furnishing his. bid Detailed survey shall be carried out by Bidder after award of work and all findings as stated earlier shall be submitted for Owner's review.

Before commencement of cutting/filling, all organic and vegetable matters like grass. Plants shrubs bushes, weeds, trees (with girth less than 30 cm measured at height of 1m above ground level) etc. in the areas to be filled, shall be completely removed along with their roots and disposed off. .It shall also be ensured that the area to be filled is clear of any water, slush etc. Original ground shall be compacted by rolling as directed by the Engineer subject to a minimum of six passes of 8 to 10 tonne roller The earth shall then be spread in horizontal layers not exceeding 300 mm in compacted thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may by required to obtain a compaction of 95% or more of Standard Proctor's maximum dry density. The moisture content of the fill material shall be controlled to obtain near optimum moisture content during compaction.

The fill material shall be tested for determining optimum moisture content and maximum dry density by Standard Proctor Test as per IS : 2720 (Part-VII). The fill material shall also be tested for determining moisture content before compaction as per IS:2720 (Part-II) For each of the above tests, one sample for every 10,000 cubic metre of fill material shall be tested. Additional samples shall be tested, whenever there is a change in the source or type of fill material. The compacted soil shall be tested for its dry density as per IS2720 (Part-XXIX) or Part-XXVIII). Samples shall be taken at the rate of one sample for every 10,000 sq.m. area for each compacted layer. In addition random checks shall be carried out in compacted soils by means of Proctor needle penetration. Bidder shall submit to the Engineer, the test results immediately after completion of the tests. A sample shall be deemed to have passed the test when the in-situ dry density is equal to or more than the specified percentage of maximum dry density. If a sample taken from a layer fails to pass the test, the layer shall be further compacted till two samples

taken and tested from this layer pass without any negative deviation. Only after this. spreading of further layers shall be taken up.

Before start of filling, the Bidder shall submit to the Owner his proposal for the methodology to be adopted for compaction for each type of fill material. The Bidder shall also carry out compaction trials to establish the proposed methodology. The Bidder shall start the compaction work only after approval of the methodology by the Owner

The surface of the cut/filled up areas after reaching final level shall be dressed to the required levels and slopes. The difference in levels shall not be more than +/- 10cm
locally.

The borrow areas outside the overall plant boundary limits for obtaining suitable fill material which is required over and above the earth available after cutting high grounds within the plant area, for site levelling shall be arranged by the Bidder himself and all expenses in respect of royalties, taxes, duties, etc. for borrow areas/fill material shall be borne by him. He shall also obtain and submit to the Owner the necessary clearances/permission from the concerned authorities for the borrow areas/fill material.
Material suitable for filling shall be loaded and transported to the filling site by the Bidder.

Any coarse grained or fine grained low plastic soil, free from shingle, salts, organic matter, sod or any other foreign substances, may be used for filling. The Bidder shall test the fill material to establish its suitability and submit its results to the Owner. Fill material shall be approved by the Owner. The following types of materials shall not be used for filling:

a) Material from swamps, marshes and bogs.

b) Expansive clays

c) Peat, logs, stumps, sod and perishable materials.

d) Materials susceptible to combustion

e) Any material or industrial and domestic produce which will adversely affect other materials in the work.

f) Materials from prohibited areas

Bidder shall include in his offer any extra filling that may be required on account of subsidence of the original ground due to overburden of filling above and/or compaction works for site levelling.

After levelling, the contractor shall establish concrete pillars at the intersection points of the grid lines for future reference. These pillars shall project at least 450 mm above the formation level and shall be labelled permanently with their respective coordinates and reduced levels.

Filling upto the specified formation level shall extend at least 2.0m beyond the outside face of boundary wall/fence. Thereafter, it shall be finished at a suitable slope (not steeper than 1 Vertical:2 Horizontal) and provided with good quality dry stone pitching minimum 300mm thick for slope upto level difference of 3m. If the level difference is more than 3m, the stone pitching shall be provided with RCC bands with suitable design and benching.

11.00.00 FENCING

Fencing with toe wall and steel gates shall be provided around the gypsum storage area , lime storage area , gypsum dewatering area , truck hopper and associated areas . Fencing shall comprise of PVC coated GI chain link fencing of minimum 8G (including PVC coating) of mesh size 75 mm and of height 2.4 m above the toe wall. The diameter of the steel wire for chain link fence (excluding PVC coating) shall not be less than 12G. All Fence posts shall be of 75 x 75 x 6 MS angles spaced at 2.5 m c/c distance. All corner posts will have two stay posts and every tenth post will have transverse stay post. Suitable R. C. C. foundation for the post and stays shall be provided based on prevailing soil conditions. Gates shall be sturdy with locking provisions.

Toe walls of brick masonry shall be provided between fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200 mm above the formation level with 50 mm thick P. C. C. coping (1: 2. 4) and shall extend minimum 300 mm below the formation level. Toe wall shall be plastered on both sides and painted with two coats of cement paint of approved colour and shade. Toe wall shall be provided with weep holes at suitable spacing.

12.00.00 ROADS

All roads shall be of rigid pavements unless otherwise specified. The design of rigid pavement shall be carried out as per IRC: 58. The effects of design wheel load, maximum tyre inflation pressures, tyre contact area for the vehicle, traffic loads, environmental factors such as temperature changes in the pavement, other factors, like impact, load repetitions, etc., are to be taken. Detailed plate load tests to determine the modulus of sub grade reaction “K” shall be carried out as per the procedure outlined in IS: 1888. The design traffic load shall be a minimum value of 4 million standard axles. The road shall be designed for 30 years of life and considering a minimum traffic growth rate of 1 per cent per annum. The concrete pavement for roads shall be minimum 250 mm thick slab.

The road construction including its shoulders, base, sub base and concrete pavement shall be as per IRC standards. IRC: 58 shall be followed for the pavement design and IRC: 15 shall be followed for the construction of the concrete pavement.

The road base shall be with minimum 150 mm thick dry lean concrete over granular sub base. Dry lean concrete shall be laid by a mechanical paver and compacted by vibratory rollers. Concrete pavement of the road shall be done with fully mechanized paver fitted with electronic sensors for construction techniques. Dry lean concrete

shall be minimum M10 grade and concrete pavement slab shall be minimum M35 grade concrete.

The finished top (crest) of all roads shall be 350 mm above the surrounding finished ground level.

The sub grade under all roads and its shoulders shall be compacted to achieve 95 per cent or more of Standard Proctor's Density MDD using mechanical means.

Cutting / extending / rerouting / remaking of existing roads including associated works to maintain continuity of road system / network shall also be carried out.

All culverts and RCC bridges at crossings of all roads / rail tracks / facilities with drains / nallahs / channels / roads / rail tracks / pipes / other facilities, etc. are to be designed and constructed.

Unless otherwise specified, all roads shall be double lane roads.

The road section should be as per drawing no. 4410-999-POC-F-001.

13.00.00 GATE ALONG BOUNDARY WALL:

The gates shall be provided at the entry and exit of truck movement road gates in Bidder's Scope are as identified in Drawing No.: 4410-999-POC-F-001.

The gate shall comprise of two mild steel double panelled openable shutter of minimum 7.75 m clear width and minimum height of 3.0m from top of road.

The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement, tempered steel pivot, guide track of MS tee, bronze aluminum ball bearing, castor wheel etc.

All gates shall be given anti-corrosive treatment in three coats.

The structural steel shall confirm to IS: 2062 (latest) and all other relevant IS codes.

Beside the each gate one room of size not less than 3m X 3m shall be provided for security guards. The room shall be made of brick/ RCC and with RCC roof. In addition to the room, one toilet block shall also be provided.

14.00.00 LIME & GYPSUM HANDLING AND ASSOCIATED BUILDINGS STORM WATER DRAINAGE SYSTEM

Storm water drain shall be designed taking into account the finished ground levels of the plant area, drainage pattern, intensity of rainfall, etc with a return period of 50 years. These values shall be based on rainfall intensity of 90mm/hr. All RCC drains shall be either RCC Cast-in-Situ or RCC Pre-cast drains. The minimum grade of concrete shall be M25 for RCC Cast-In-Situ drains and M30 for RCC Pre-cast drains. The maximum velocity for RCC open drains shall be limited to 1.8 metre per second. However, minimum velocity of 0.6 metre per second for self - cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided.

Open RCC rectangular section, unless required otherwise due to functioned requirement, shall be provided for all drains. The thickness of side walls and bottom slab of RCC drains shall be minimum 150mm or as per design considerations

whichever is higher for drains upto depth of 1m from formation level. For depth of drain more than 1m from formation level, the thickness of side walls and bottom slab of RCC drains shall be minimum 200mm or as per design considerations whichever is higher. The drains shall be provided on both sides of roads .These shall be designed to drain the road surface as well as all the free and covered areas, etc. Box culverts shall be provided at all rail, road and other crossings.

All drains inside the building shall have minimum 40 mm thick grating covers. In areas where heavy equipment loads would be coming, precast RCC covers shall be provided in place of steel grating.

The invert levels of the in-plant and plant peripheral drains shall be kept such that water can be discharged by gravity to the main / trunk drains under all conditions.

The invert levels of the drains shall be decided in such a way that the water can easily be discharged to the natural water bodies above the high flood.

15.00.00 **SEWERAGE SYSTEM**

The connection of sewer pipe line for the associated buildings of FGD and Lime and gypsum handling area to nearest owner's sewage network is in bidder's scope.

Cement concrete pipes of class NP-3 as per IS:458 shall be used below ground level for sewage disposal in all areas . However, for pressure pipes and under roads spun C.I. pipes conforming to IS:1536 of required class shall be used.

RCC manholes with CI cover shall be provided at every 30m along the length, at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline. This shall be as per IS:4111.

Sewage pump house shall be provided as per IS:4111.

16.00.00 **LOADING**

16.01.00 For consideration of loads on structures IS : 875 - 'Code of practice for structural safety of buildings' shall be followed. In addition to the dead load, live load, equipment load (including impact / vibration). Temperature loads etc. various loading conditions arising due to operation and maintenance of equipment shall be considered in the design. The structure and equipment shall also be designed for seismic loads as per the **"Criteria for Earthquake Resistant Design of Structures and equipment"** and the **"Criteria for Wind Resistant Design of Structures and equipment"** specified in the **"Annexure-A"** and **"Annexure-B"** respectively in Civil Section, whichever is governing. Wind and seismic forces shall not be considered to act simultaneously. The following minimum live loads shall be adopted for the design of various structures. If actual expected load is more than the specified load, then actual load is to be considered.

CLAUSE NO.	TECHNICAL REQUIREMENTS	
	a) Roofs	150 Kgs. / Sq. M. for accessible roofs and 75 Kgs. / Sq. M. for non - accessible roofs. In addition to this dust load (Dead load) of 150 Kgs. / sq. m. on flat roofs & 75 Kgs. / sq. m. on inclined roofs shall also be considered.
	b) R. C. C. floors	500 Kgs. / Sq. M.
	c) Stair and balconies	500 Kgs. / Sq. M.
	d) Toilet rooms	200 Kgs. / Sq. M.
	e) Chequered plate floors	400 Kgs. / Sq. M.
	f) Walkways (including walkways in conveyor galleries)	300 Kgs. / Sq. M.
	g) Conveyor galleries	In addition to the live loads, loads due to cable trays, fire fighting / service water pipes shall also be considered @ 125 Kgs. / m (minimum) on each of the longitudinal girder. Roof-truss members are to be checked for supporting fire fighting pipes/ Service water pipes.
	h) Road Culverts and its allied structures including R. C. C. pipe crossing & road crossing of trenches.	For class 'AA' loading and checked for class A loading as per IRC standard.
	i) Channels / trenches	In addition to earth pressure and water pressure, etc. additional earth pressure due to surcharge of 2T / Sq. M. shall also be considered for design.
	j) Covers for trenches / channels	Covers for channels & trenches, shall be designed for a live load of 0.4T Sq. M. and loading as mentioned under clause in trenches, whichever is critical.
	k) Sumps and tanks and other underground basement type structures	In addition to earth pressure with a surcharge of 2T / Sq. M. (or surcharge due to Railway loading whichever is critical for Railway load bearing structures etc.) and sub - soil water pressure etc. These are also to be designed for the following conditions : i) Water / liquid inside and no earth outside (applicable only to such

structures which are liable to be filled up with water or any liquid).

ii) Earth with surcharge outside and no water / liquid inside

iii) For underground (basement) structures protection against buoyancy during execution and after execution shall be ensured without superimposed loadings with minimum factor of safety of 1.2 against buoyancy.

If the erection load is higher than the specified live loads on any floor or part thereof, then the erection loads are to be considered for the design.

Permissible increase in stresses of materials and bearing pressure of soil due to wind load or seismic load shall be as per relevant I. R. S. and I. S. code.

16.02.00 **Crane load**

For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of frame according to the provisions of IS:875. The longitudinal crane surge shall be 5% of the static wheel load. Longitudinal surge and lateral surge shall not be considered to act simultaneously.

16.03.00 **Temperature load**

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint shall be as per the provisions of IS: 800 and IS: 456 for steel and concrete structures respectively.

17.00.00 **DESIGN CRITERIA**

17.01.00 The design of all R. C. C. structures shall be carried out as per ‘code of practice for plain and reinforced concrete for general building construction’, IS : 456 (latest).

17.01.00 Design of steel structures shall be done by the Working stress method. Design shall be as per provisions of IS:800 :1984 and other relevant IS standards.

17.02.00 Minimum size of the angle section to be used as structural members shall be 50 X 50 X 6. Minimum weld size shall be 6 mm. Connections shall be designed for 70 % of shear capacity of the member or the actual shear force, whichever is higher. The steel structures using tubular sections shall be designed and fabricated as per IS:806 – “Code of Practice for use of steel tubes in general building construction.” and EN 1993-1-8:2005. Minimum grade of steel & thickness of Tubular/Hollow sections shall be Yst 240 Mpa & 4.0mm respectively

CLAUSE NO.	TECHNICAL REQUIREMENTS
17.03.00	The building shall conform to local bye - laws, rules and regulations for industrial buildings and also B. I. S. publications, SP 32 and 41.
17.04.00	Slotted holes shall not be assumed to act as expansion joint for relieving of stresses and suitable bearings shall be provided at the supports.
17.05.00	Stresses for all structures shall be checked for the higher of the forces obtained from gust factor method and the peak wind speed method.
17.06.00	Horizontal bracing system shall be provided at floor levels around the openings.
17.07.00	Shear force in steel columns shall be transferred to the pedestals / foundations exclusively either through foundation bolts or the shear key arrangement.
17.08.00	For design of liquid retaining structures, IS : 3370 (Part - I to IV) (latest) shall be followed. Face of the structure in contact with liquid shall be designed as un - cracked section. For design of R. C. C. pipes for culverts, latest editions of IS : 458, IS : 783 should be followed.
17.09.00	For design of all underground structures / foundations, ground water table shall be assumed at the formation level (i. e. the adjoining ground level). For all underground structures like tunnel, underground transfer point and underground hopper etc. crack width shall be limited to 0.2mm.
17.10.00	Design of masonry walls shall be made as per IS : 1905.
17.11.00	Civil task drawing indicating various equipment loading and supporting arrangement and floor loads to be submitted along with the design calculation.
17.12.00	Minimum 0.12% of reinforcement shall be provided on the top face of the foundation concrete on either direction and minimum percentage of reinforcement at bottom face of foundation shall be same as that stipulated for beam as per IS:456.
17.13.00	Foundations for all tanks shall be designed for as per IS: 803.
17.14.00	Footings shall be so proportioned to as to minimise the differential settlement.
17.15.00	All gallery supporting trestles shall be so proportioned that the transverse deflection of gallery due to wind / seismic load should not exceed trestle height / 1000 as stipulated in IS: 11592. This deflection condition shall be strictly followed. Peak wind speed method shall be considered for checking the transverse deflection.
17.16.00	The crusher and transfer house structures shall be so designed that transverse deflection at places where conveyor galleries meet, should be equal to the respective transverse deflection of conveyor supporting trestles.
17.17.00	**Deflection criteria** The maximum Horizontal Deflection for various structures shall not exceed and be limited to the following:

Sl. No.	Description	Maximum value of
1.	For Trestles and transfer points (Transverse deflection at Conveyor gallery supporting level)	Height/1000 (For Wind load by Peak Wind Speed Method / Seismic Load)
2.	For other Buildings	Height/325

17.18.00

a) Permissible deflection (unless specified otherwise in this specification) for latticed framework and beams of floors other than drive floor shall be span/325.

b) The allowable deflection for beams directly supporting drive machinery shall be restricted to span/500 unless specified otherwise in this specification.

c) The deflection for manually operated cranes & monorail supporting beams shall not exceed span/500.

For electric overhead cranes :

1) upto 50 t capacity : span/750

2) over 50 t capacity : span/1000

d) The vertical deflection of metal deck sheet for roofing and side cladding shall be limited to span/250

e) The permissible vertical deflection for beams supporting drive machinery shall be restricted to span / 500 and for other beams it shall be within span / 325.

f) Permissible deflection for all purlins, cladding runners, roofing/cladding sheets and grating / chequered plates shall be span/250. However, the maximum vertical deflection of Grating/ Chequered plate shall be limited to 6 mm.

17.19.00

a) Dispersion of load in any direction through soil shall be as per IS: 8009 (relevant part).

b) Dispersion of load through concrete shall be considered at an angle of 45 degrees with horizontal from the edge of contact area.

17.20.00

a) The design and construction of RCC structures shall be carried out as per IS: 456. Working stress method shall be adopted for the design wherever specifically mentioned in this specification.

b) For design and construction of steel-concrete composite members, IS: 11384 shall be followed.

c) For reinforcement detailing, IS: 5525 and SP: 34 shall be followed.

d) Two layers of reinforcement (on both inner and outer faces) shall be provided for RCC wall sections having thickness 150 mm or more.

CLAUSE NO.	TECHNICAL REQUIREMENTS
17.21.00	a) All RCC liquid retaining/conveying shall be designed by working stress method as outlined in clause no. 4.5 of IS 3370 (Part-2) 2009 unless specified other wise. b) Water proofing treatment shall be provided for liquid retaining/ carrying structures and basement type structures (requiring dry working condition). Dense and durable concrete with water cement ratio not more than 0.45 shall be used. Plasticiser /super-plasticiser cum water proofing compound shall be added to the concrete. All the construction/expansion joints shall be provided with PVC water bar and/or chemical injection grouting as per IS:6494. As applicable internal/external surface of such structures shall be provided with acrylic based polymer modified cementitious composite coating system for critical structures. For liquid carrying/retaining structures, minimum two coats of such coating shall be applied. For external application wherever the surface is in contact with the earth, fine silica/quartz sand of 0.6 mm nominal size shall be added in the coating mix for better abrasion resistance and total nominal thickness of such coating shall be minimum 1.5 mm. For non critical structures minimum two coats of bitumen grade 85/25 as per IS:702, mixed with 1% of anti-stripping compound meeting the requirement of IS:6241, shall be applied. The total application of bitumen shall not be less than 1.7 kg/sq.m. Bidder shall submit a comprehensive scheme for water proofing treatment based on above or any other alternative scheme, internationally accepted for Employer's approval prior to commencement of work. c) All liquid retaining/carrying structures shall be tested for water tightness as per the provisions of IS: 3370 and IS: 6494 and in case of leakage, the same shall be rectified by chemical injection grouting through nozzles.
17.22.00	For design of all underground structures, foundations, etc. ground water table shall be assumed at the finished ground level unless specified otherwise.
17.23.00	Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest or co-efficient of active earth pressure, whichever is applicable, depending upon the structural configuration. However, for the design of substructure of pump houses, earth pressure at rest shall be considered. Co-efficient of passive earth pressure shall be used only in design of shear keys for stability against sliding.
17.24.00	a) Following loading conditions shall be considered in addition to the loading from super structure for the design of substructure of pump house, channels, sumps, tanks, trenches and other underground structures containing liquid i) Water pressure from inside and no outside pressure, like earth pressure, ground water and surcharge pressure (applicable only to structures, which are liable to be filled up with water or any other liquid.) ii) Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside. iii) Design shall also be checked against buoyancy due to the ground water during construction as well as after construction stages. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loadings. Provision of pressure relief valves/flap valves, etc., shall not be permitted to counter the buoyancy unless specified otherwise. iv) Base slab and piers of the pump houses shall also be designed for the

condition of different combination of pump sumps being empty during maintenance stages with maximum ground water level.

b) Intermediate dividing pier of pump sumps and partition wall (if applicable) in channel shall be designed considering water on one side only and other side being empty for maintenance.

c) All pump houses and other substructures (wherever applicable) shall be checked for stability against sliding and overturning during construction as well as operating conditions for various combinations of loads.

17.25.00 **Design of Block Foundation**

a) Block foundation resting on soil shall be analyzed using elastic half space theory. In case the foundation is supported over piles, Novak's approximation shall be used for determining the spring constant and damping ratio of pile groups. The mass of the RCC block shall be at least three times the mass of machine. Free vibration analysis of the foundation shall be carried out to evaluate the natural frequencies. The fundamental natural frequency shall be kept at least 20% away from the operating frequency (speed). Forced vibration analysis shall be carried out if the dynamic forces are made available by the machine supplier in which case the amplitude limits stipulated by the machine supplier and ISO 10816, whichever is lower, shall be satisfied.

Reinforcement design shall be done by working stress method as per IS:456-2000 and IS:2974 (Part-IV).

b) For the foundations supporting minor rotating equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structure, floors, etc., suitable vibration isolation shall be provided by means of springs, neoprene pads, etc., and such vibration isolation system shall be designed suitably.

18.00.00 **Coating on RCC water retaining structures (other than drinking water)**

Epoxy phenolic coating shall be applied on internal surfaces of the RCC water retaining structures, as per details specified below:

All concrete surfaces shall be provided with two component transparent polyamide cured epoxy sealer coating (having solid by volume minimum 40% ±2%) of minimum 50 micron DFT. Surface to be coated shall be absolutely dry, clean and dust free.

Sealer coat shall be followed with the application of epoxy phenolic coating (solid by volume minimum 63%) of minimum 400 micron DFT. This coat shall be applied after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.

Coating on RCC water retaining structures (drinking water)

Internal surfaces of RCC water retaining structures shall be provided with minimum 400 micron Food grade epoxy coating complying to FDA Title 21, Part 175.300. Surface to be coated shall be absolutely dry, clean and dust free

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CLAUSE NO.	TECHNICAL REQUIREMENTS
19.00.00	**Fabrication** All steel structures shall be fabricated in factory, transported and erected at site. All factory fabricated structures shall have bolted field connections. Chimney flue liners can either be fabricated at factory in segments, transported and welded at site before erection or fabricated at site. For Chimney flue liners, to prevent flue gas leakages, the applicable field joints shall necessarily be welded.
20.00.00	**Electrodes**
20.01.00	The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired. Only low hydrogen electrodes shall be used for welding of medium / high tensile steel and for mild steel plate thickness above 20 mm.
20.02.00	All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250^{o}C - 300^{o}C for one hour and later on cooled in the same oven to 100^{o} C. It shall be transferred to a holding oven maintained at 60^{o}C - 70^{o}C. The electrodes shall be drawn from this oven for use.
20.03.00	Where coated electrodes are used they shall meet the requirements of IS: 814 and relevant ASME - Sec. II. Covering shall be heavy to withstand normal conditions of handling and storage.
20.04.00	Only those electrodes that give radiographic quality welds shall be used for welds, which are subjected to radiographic testing.
20.05.00	Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS: 3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.
20.06.00	The contractor shall take specific approval of the weld for the various electrodes proposed to be used on the works before any welding is started.
20.07.00	**Edge Preparation for Welding** Suitable edge as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.
20.08.00	**Pre Heating and Post Heating** Mild steel and medium / high tensile steel plates thicker than 20mm, will require Pre-Heating of the parent plate prior to welding as mentioned in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, however, higher pre heat temperature may be required as per approved welding procedure and it shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose. Base metal shall be preheated, not withstanding provisions of IS: 9595 to the temperature given in Table - 1 for mild steel and Table - 2 for medium / high tensile

steel, prior to welding or tack welding. When base metal not otherwise required to be pre heated is at a temperature below 0°C it shall be pre heated to atleast 20°C., prior to tack welding or welding. Pre heating shall bring the surface of the base metal to the specified pre heat and this temperature shall be maintained as minimum inter-pass temperature welding is in progress.

TABLE - 1
MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR WELDING MILD STEEL

Thickness of thicker part at Point of welding	Welding Using: Low hydrogen electrode or submerged arc welding	Welding Using: Other than low hydrogen electrode
Upto and including 20mm	None	None
Over 20mm and up to and including 40mm	20°C	Not allowed
Over 40mm and up to and including 63mm	66°C	Not allowed
Over 63mm	110°C	Not allowed

Note: Type of electrode and the preheating requirements for welding shall be as per approved welding procedure.

TABLE - 2
MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR WELDING MEDIUM / HIGH TENSILE STEEL

Thickness of thicker part at Point of welding	Welding Using: Low hydrogen electrode or submerged arc welding	Welding Using: Other than low hydrogen electrode
Upto and including 20mm	None	Not Allowed
Over 20mm	120oC - 140°C	Not Allowed

Note : Type of electrode and the preheating requirements for welding of medium and high tensile steel shall be as per approved welding procedure.

20.09.00 Pre heating may be applied by external flame which is non-carbonizing like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the welded joint is obtained.

CLAUSE NO.	TECHNICAL REQUIREMENTS
20.10.00	Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.
20.11.00	All butt welds with plates thicker than 50mm and all site butt welds of main framing beam supporting the bunker shall require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done up to 600oC and rate of application shall be 200oC per hour.
20.12.00	The post heat temperature shall be maintained for 60 minutes per 2.5cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas.
21.00.00	**Paving, Drainage and Sewage**
	RCC paving of minimum 150 mm thick with M25 grade concrete, over an underbed as specified herein shall be provided. RCC paving shall be designed as rigid reinforced concrete pavement for the crane/ vehicular/ equipment movement loads which the paving has to bear. The under bed for paving shall consist of preparation and consolidation of sub-grade to the required level, laying of stone soling of 200mm compacted thick for normal duty paving with 63 mm and down aggregate with interstices filled with selected moorum followed by 75 mm thick 1:4:8 PCC (1 part cement, 4 parts sand and 8 parts stone aggregate) with 40 mm nominal size aggregate. Paving areas shall be provided with the metallic hardener floor finish as specified elsewhere in the specification. 2.5 m wide paving with metallic hardener around periphery of all sumps and underground tanks shall be provided. Suitable drains shall be provided to dispose off storm water as well as floor wash of the FGD area block. The paving shall be provided with slope of 1:500 to dispose the surface water/wash water to the nearest drain. Sewer lines (Cast Iron), interconnected by sewer manholes (RCC) at regular intervals (not exceeding 30 meter centre to centre) shall be provided to dispose off sewage from FGD area to the nearest available manhole of the owner. The plant storm water drainage shall be designed taking into account the finished grade levels of the plant area, drainage pattern, intensity of rainfall, etc., The storm water drainage shall cater to storm water run off resulting from one hour rainfall intensity, with a return period of 50 years. The value of minimum rainfall intensity shall be taken as 75mm/hr. The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8 m/sec. respectively. However, minimum velocity of 0.6m/sec. for self-cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided. The open drains shall be open rectangular drains of RCC unless required otherwise due to functional requirement. RC box culverts shall be provided at rail, road or other crossings. Sewers shall be designed for a minimum self-cleansing velocity of 0.75m/sec and the maximum velocity shall not exceed 2.4m/sec.

22.00.00 Statutory Requirements

Bidder shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules at Tariff Advisory Committee. Water Act for pollution control, Explosives Act, etc.

Provisions of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkways along the crane - girder level on both sides of building, comfortable approach to EOT crane cabin, railing, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Provisions for fire proof doors, number of staircases, fire separation wall, lath plastering/encasing the structural members (in fire prone areas), type of glazing etc. shall be made according to the recommendations of Tarrif Advisory Committee.

Statutory clearances and norms of State Pollution Control Board shall be followed.

Bidder shall obtain approval of Civil/Architectural drawings from concerned authorities before taking up the construction work.

23.00.00 INSPECTION, TESTING AND QUALITY CONTROL

Sampling and testing of major items of civil works viz. earthwork, concreting, structural steel work (including welding), piling, sheeting, etc. shall be carried out in accordance with the requirements of this specification. Wherever nothing is specified relevant Indian Standards shall be followed. In absence of Indian Standard equivalent International Standards may be used.

The Bidder shall submit and finalise a detailed field Quality Assurance Programme before starting of the construction work according to the requirement of this specification. This shall include frequency of sampling and testing, nature/type of test, method of test, setting of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of format for record, Field Quality Plan, etc. Tests shall be done in the field and/or at a laboratory approved by the Engineer. The Bidder shall furnish the test certificate from the manufacturer's of various materials to be used in the construction.

24.00.00 CONCRETE

All R. C. C. works to the done under this specification, unless specified otherwise shall be design mix concrete. Minimum grade of concrete for various structures shall be as follows:

a) M25 - For all underground / sub-structural/ super-structure R. C. C. work.

b) M30- For Block Foundation

c) M35- For spring supported RCC deck

CLAUSE NO.	TECHNICAL REQUIREMENTS
	Minimum 75 mm thick P.C.C M-7.5 shall be provided as mud mat below all foundations. For concreting of underground structures requiring water tightness, plasticizer cum water proofing admixture shall be added to the concrete mix. Both coarse and fine aggregates shall conform to IS: 383 for concrete, shotcreting etc. unless otherwise mentioned.
25.00.00	**Excavation, Backfilling, Disposal and Stacking of materials Details**
25.01.00	**Excavation in Soil** Excavation for foundation shall be to the bottom of lean concrete and as shown on drawing or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels by error, it shall be brought back to the specified level by filling with concrete of nominal mix 1 : 3 : 6 (cement: coarse sand: 40 mm down aggregates), as directed by the Engineer. The Contractor shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Cofferdams, sheet piling, shoring, bracing to maintain suitable slopes, draining etc. shall be provided and installed by the contractor, to the satisfaction of the Engineer. Surplus excavated materials shall be disposed off by the contractor at locations up to a lead of 5 kms from the plant boundary wall as directed by the engineer. The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, springs etc. and maintain dry working conditions at all times until the excavation, placement of reinforcement, shuttering, concreting, Backfilling is completed. The Contractor shall remove all slush/muck from the excavated areas to keep the work area dry. The Contractor, if required, shall employ sludge pumps, for this purpose. For other details, excavation clauses as given at Annexure-C of this specification, are to be referred.
25.02.00	**Excavation in Rock** For the work of excavation in rock, Contractor shall engage specialised agency having experience of excavation in rock involving wedging and blasting. The agency shall be subject to approval of Engineer and the Contractor shall furnish details of relevant experience in support while seeking approval for the agency. Blasting shall be resorted to only with the written permission of the Engineer. All the statutory laws, (Explosives Act etc.) rules, regulations, Indian Standards etc. pertaining to the acquisition, transport, storage, handling and use of explosives etc. shall be strictly followed.

The contractor shall obtain Licenses from Competent Authorities for undertaking blasting work as well as for procuring, transporting to site and storing the explosives as per Explosives Act. The Contractor shall be responsible for the safe transport, use, custody and proper accounting of the explosive materials.

Surplus excavated materials shall be disposed off by the contractor at locations up to a lead of 5 kms from the plant boundary wall as directed by the engineer.

The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, springs etc. and maintain dry working conditions at all times until the excavation, placement of reinforcement, shuttering, concreting, backfilling is completed. For other details forexcavation in rock, clauses as given at Annexure-C of this specification, are to be referred.

25.03.00 Backfilling, Disposal and Stacking of materials

Backfilled earth shall be compacted as per “Foundation system and Geotechnical Data Chapter” given at Annexure-C of this specification.

However, the backfill under the rail lines and roads shall be compacted to minimum 95 % of the standard proctor density at OMC unless otherwise stated by rail Authorities.

The contractor is required to excavate upto any depth as shown on the drawings or as directed by the Engineer. Lifting of excavated materials shall be done either by manual or mechanical or both means if called for by the Engineer.

The disposal / stacking areas for excavated materials shall be indicated by the Engineer. The carriage of excavated materials shall be done by the methods mentioned below:

The excavated materials shall be carried beyond the initial lead of 50 m but upto 500 m by manual / animal labour or by mechanical means. If directed by the Engineer this material shall be used directly for filling purposes.

For leads exceeding 500 m the Contractor shall transport the excavated materials by mechanical means only and as directed by the Engineer. The Contractor may be allowed to carry materials through Kuccha roads. Providing and maintaining of the Kuccha roads shall be the responsibility of the Contractor. The transported material shall be neatly stacked as directed by the Engineer.

Some excavated materials required for filling purposes, may have to be carried upto a lead of 500 m and stacked as per instructions of the Engineer. Excavated materials carried beyond 500 m shall normally be for disposal purpose only. Double handling of materials shall be avoided as far as possible. However, depending on site condition excavated materials carried beyond a lead of 500 m may also be required to be brought back for filling purpose.

Materials to be used for filling purpose shall be stone, sand or other inorganic materials and they shall be clean and free from shingle, salts, organic matter, large roots and excessive amount of sod, lumps, concrete or any other foreign substances which could harm or impair the strength of the substances in any manner. All clods

shall be suitably broken to small pieces. When the material is mostly rock boulders, these shall be broken into pieces not larger than 150 mm size before backfilling and shall be backfilled in layers of 300mm interstices filled with sand. In case of broken rock boulders used for back filling, the top cover shall be with 1.0m thick soil. The layers of rock boulders, interstices filled with sand shall be compacted by plate vibrators. Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 75 microns shall not be more than 20%. In any case, the materials to be used for filling purposes shall have the prior written approval of the Engineer.

In case the materials have to be brought from pits / quarries, then it shall be the Contractor's responsibility for identification of such quarry areas, obtaining approval from their use from concerned authorities, excavation / quarrying loading and carriage of such material, unloading and filling at specified locations. The Contractor shall pay any fees, royalties etc. that may have to be pain for utilisation of borrow areas.

26.00.00 GALVANISING

All burrs and irregular edges of the structural steel members to be galvanised shall be ground smooth before galvanising.

Purity of Zinc to be used for galvanising shall be 99.5 % as per IS : 209 (latest edition).

The weight of the zinc coating shall be at least 610 Gms. / m^2 unless noted otherwise.

27.00.00 CHEMICAL INJECTION GROUTING

Minimum, 12 mm dia (NB) threaded nozzle of suitable length, shall be provided over the surface and along the construction joint line in a grid pattern at a spacing not exceeding 1.5 m c / c before concreting operation. Adequate precaution shall be taken to keep the nozzles plugged at both ends to prevent them from getting closed by concrete.

For fixing of any nozzle in set concrete suitable size hole shall be drilled, preferably by using repercussive hammer drill electrically operated, in grid pattern and grouting nozzle shall be fixed in these holes.

After the nozzles are fully set, neat cement slurry admixed with water soluble non - shrink polymer / monomer based chemical shall be injected through the net - work of nozzles with low pressure grout pumps at a pressure of about 2.0 Kgs. / cm^2. Cement slurry shall be prepared by mixing cement with non-shrink polymer/monomer @ 500 gm/50 kg bag of cement and water, ensuring that Water: Cement ratio does not exceed 2 (by weight). Wetter the structure, lesser should be the water cement ratio. The property of the polymer/monomer should be such that when it is mixed with water @0.5% by weight of water, the viscosity of the resultant solution (water and polymer/monomer) should not be more than 1.2 centipoises. Plasticizing agent shall be added wherever required. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue, till the hole refuses to take any further grout, even at an increased pressure. Applied pressure

shall not be more than the designed strength of the concrete. After completion of grouting operation, the nozzles shall be sealed properly to the satisfaction of the Engineer.

28.00.00 POLYMER MODIFIED CEMENTITIOUS COATING

28.01.00 Materials

Modified liquid polymer blend shall be a dispersion containing 100 % acrylic based polymer solids. Polymer shall be mixed in the ratio of 1 cement: 0.5 polymer (for minimum solid content of polymer 30%).

Portland cement based dry powder.

Clean, fine specially prepared quartz sand approximately 0.6 mm size.

28.02.00 Mixing

The liquid polymer shall be stirred well and cement based powder shall then be added slowly to make a Slurry Mix. For preparation of Brush Topping Mix, quartz sand shall be added slowly and mixed well till a homogeneous mixture is obtained. The mix shall be used within half an hour of the preparation. Addition of quartz sand may not be necessary, in case dry power contains the same.

28.03.00 Properties of Coating

It must adhere to wet surface.

It should develop adequate bond strength, with the concrete surface, not less than 2 N / Sq. mm.

Co - efficient of permeability shall be about $5x10^{-10}$ Cm / Sec.

Water absorption after continuous soaking shall not be more than 1 %.

The materials shall be permeable under water vapour.

The material shall be resistant to acids and alkalies present in the soil and underground water with normal pH value between 4 and 14.

The co - efficient of thermal expansion of the material shall be close to that of concrete.

28.04.00 Application

The concrete surface shall be cleaned and made free from grease, oils or loosely adhered particles. The surface shall be damp without any free water. For exterior underground part, application (b) pertaining to Brush topping Mix shall be followed.

(a) For Slurry Mix

A minimum of 2 coats shall be applied on the surface. The first coat being applied, when the surface is still damp and left to harden for 4 to 6 hours. After 4 to 6 hours of the application of second coat, it shall be finished by rubbing down with a soft dry sponge. The coverage shall not be less than 1 : 1 Kgs. / m^2 in the 2 coats. A lap of 75 mm shall be provided at the joints.

The coating shall be air dried for 4 to 6 hours and, thereafter, cured for 7 days after the application of last coat.

(b) For Brush Topping Mix

This shall be applied in two coats. A primary coat of slurry mix can also be first applied on the surface as first coat. After the coating has dried up, a coat of Brush Topping Mix shall be applied over it with a push broom or any other similar brush. It shall be left in broom finished condition. The nominal thickness shall be 1.5 mm and minimum thickness shall be 1.0 mm. A lap of 75 mm shall be provided at the joints. It shall be ensured that no pinhole exists and rebrushing shall be done to cover the pinholes, if any.

The Coating shall be air dried for 4 to 6 hours and thereafter cured for 7 days after the application of last coat.

Rate of application of coating shall be established to achieve the required thickness.

29.00.00 Architectural Concepts

Buildings shall be architecturally treated in such a way that it presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses. The overall impact of the building shall be one of aesthetically unified architectural composition having a comprehensive scale, blending with the surroundings and taking full consideration of the climatic conditions and the building orientation. All the buildings shall be architecturally treated in such a way so as to be in harmony with the surroundings. The over all composition may have straight or curvilinear profiles.

Necessary projections, fins, parapets, chajjas etc. in addition to the minimum area specified elsewhere in this specification shall be provided as required.

Nothing extra shall be payable for any changes required while getting the drawings / scheme approved and for executing the same.

All structures, buildings and facilities shall be designed as per provisions of National Building Code 2005 and Local building by - laws as applicable including provisions of the Factories Act of the State concerned, with regard to requirement of free access, stairs, minimum head room, walkways, ventilation, toilets etc. and safety requirements like railings, fire escapes etc. Further all layouts and detailed drawings shall meet the relevant statutory requirements specified in recommendations of Petroleum act, Explosives act and Indian Electricity rules' as applicable.

CLAUSE NO.	TECHNICAL REQUIREMENTS
29.01.00	**FINISHING SCHEDULE**
29.01.01	**Flooring** The nominal total thickness of floor finish shall be 50mm i.e. underbed & topping. The floor shall be laid on an already laid and matured concrete base. Flooring of tiles / stone shall be fixed with 18 mm thk cement sand mortar 1:4, above PCC under bed (M 20 (with graded aggregate of nominal size 12.5mm) design mix) Flooring of Concrete hardener topping shall be provided above the PCC underbed (M 20 (with graded aggregate of nominal size 12.5mm) design mix).
29.01.02	Wherever specified Heavy duty ceramic tiles of size 300x300x7 mm thick (minimum) of reputed manufacturer (Kajaria, Orient, Johnson or equivalent) of approved finish shade and colour to be used. Vitrified ceramic tiles wherever specified shall be 600x600 mm with minimum 9.5 mm thickness and of reputed manufacturer (Kajaria, Johnson, Orient or equivalent).
29.02.00	**Floor finish & skirting:** The nominal thickness of floor finish shall be 50 mm. Floors of toilets, pantries / kitchen shall be finished with Heavy duty (grade-5) dust pressed ceramic tiles 300mmx300mm x7 mm thick as per IS:15622, including pointing the joints with white cement mixed with matching pigment, of approved make, size & colour shade. (1) Floors of Office Room, Labs, Control Rooms, RIO Rooms and all other A/c Room shall be finished with Mirror polished Vitrified ceramic tiles (minimum 9.5 mm thk) with 3 mm groove joints as per approved pattern, pointed neatly with 3X4mm stainless epoxy grout SP- 100 of Laticrete or approved equivalent in approved colour to match colour of tile. (2) Suitable supporting arrangement shall be provided with M.S. angles / channels on cable trenches in MCC and Control rooms for mounting Control panels / MCC. (3) In rest of the areas, IPS (Cement concrete flooring) with Concrete hardener topping shall be 12mm thick with ordinary grey cement using uniformly graded, properly treated iron particles shall be provided. (4) Floors and sides of under ground RCC structures like valve pits, trenches and tanks shall have simultaneous (integral) neat cement finish at the time of concreting. (5) The interconnecting walkway between various structures, buildings and facilities shall be finished with 22 mm chequered concrete tiles at top. 1000 mm wide walkway of 22mm thick chequered concrete tiles shall be provided on terrace for maintenance purpose, in all RCC /Metal deck roof buildings. (6) Skirting in general shall be 150mm high, Dado in toilet, kitchen & pantry shall be up to specified height (up to 2200 mm for toilets, up to 600 mm high above counter top in kitchen and pantry area). The dado height shall be measured from finished floor level. Skirting and Dado shall match with the floor finish.

(7) Battery Room shall be provided with Acid resistant tile on horizontal and vertical surfaces, at all levels for all type of works, including One coat of bitumen primer followed by 12 mm thick bituminastic layer, 20 mm thick Acid Resistant tiles, 6 mm thick under-bed by potassium silicate mortar, 6 mm thick pointing of joints of tiles with acid/alkali resistant epoxy/furane mortar up to a depth of 20 mm and bituminastic end sealing. 1200 mm high dado on wall shall be with 12 mm thk Acid resistant tiles of the similar finish and the joints to be finished as per flooring tiles, with the rest of wall height and ceiling finished in chemical resistant paint (chlorinated rubber based).

(8) Well polished 18 mm thick Kota stone jointed with neat cement slurry mixed with pigment to match the shade of the stone including rubbing and cleaning, complete, to be provided in entrance area, entrance steps, Entrance area, staircases (tread, riser, landings, skirting).

29.03.00 Sunken RCC slab shall be provided in false flooring area and toilet, Kitchen and pantry, so as to keep the finished floor level of these areas same as that of the surrounding area.

29.04.00 Water proofing treatment to be provided on sunken portion of all vertical and horizontal surfaces of depressed portions of all toilets, W.C., kitchen, Pantry and the like consisting of :

(i) Ist course of applying cement slurry @ 4.4 kg/sq.m mixed with water proofing compound conforming to IS 2645 in recommended proportions including rounding off junction of vertical and horizontal surface.

(ii) IInd course of 20 mm cement plaster 1:3 (1 cement: 3 coarse sand) mixed with water proofing compound in recommended proportion including rounding off junction of vertical and horizontal surface.

(iii) IIIrd course of applying blown or residual bitumen applied hot at 1.7 kg. per sq.m of area.

(iv) IVth course of 400 micron thick PVC sheet. (Overlaps at joints of PVC sheet should be 100 mm wide and pasted to each other with bitumen @ 1.7 kg/sq.m).

29.05.00 **Acid / Alkali Resistant Treatment:**

Acid / alkali resistant lining treatment shall be provided in different areas as follows:

Neutralization Pit: The walls shall be provided with one coat of bitumen primer, followed by 18 mm thick bitumastic layer, 115 mm thick A.R. bricks, 6 mm thick under bed of potassium silicate mortar, pointing the joints of bricks with acid / alkali resistant epoxy / furane mortar upto a depth of 20 mm and bitumastic end sealing. Suitable plasters shall be provided with A.R. bricks at regular intervals depending upon the height of lining, as per the specification.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	The floor of neutralization pit shall be provided with acid / alkali resistant lining treatment as given in the above para, except that the 115 mm thick A.R.tile layer shall be replaced by 75 mm thick A.R. tile layer and pilasters shall be omitted. The ceiling of neutralization pit shall be provided with one coat of epoxy primer followed by 2 coats of epoxy paint (150 micron). Acid / Alkali storage area / projections above the floor, pedestals projecting from the floor / saddles. : The floor shall be provided with one coat of bitumen primer followed by 12 mm thick bitumastic layer, 20 mm thick A.R. tiles, 6 mm thick under - bed by potassium silicate mortar, 6mm thick pointing of joints of tiles with acid / alkali resistant epoxy / furane mortar up to a depth of 20 mm and bitumastic end sealing. Dado of 12 mm thk Acid Resistant tiles up to 1.0M high shall also be provided if applicable in case of walls nearby. Alum/Lime Storage area and first floor of Chemical House : One coat of bitumen primer followed by 12mm thick bitumastic layer, 20 mm thick A.R. tiles, 6 mm thick underbed of potassium silicate mortar, 6mm thick pointing of joints of tiles with acid /alkali resistant epoxy /furane mortar up to a depth of 20 mm and bitumastic end sealing. Alum solution preparation tank: The wall shall be provided with one coat of bitumen primer followed by 12 mm thick bitumastic layer, 75 mm thick A.R. tiles, 6 mm thick underbed by potassium silicate mortar, pointing of joints of tiles with acid / alkali resistant epoxy / furane mortar upto a depth of 20 mm and bitumastic end sealing. The floor shall be provided with acid / alkali resistant lining treatment as given in the above para except that the 75 mm thick A.R. tile layer shall be replaced by 12 mm thick A.R. tile layer. Basket of Alum solution preparation tank: 5 mm thick epoxy lining over a coat of epoxy primer. Curved surfaces of saddles shall have minimum 12 MM thick bitumastic layer to support the vessel / tanks. Effluent Drains: Acid Resistant lining treatment indicated for the storage area shall be provided on the bed as well as walls of the drains with 38 MM AR tiles. The underside of the pre-cast slab cover shall be applied with one coat of epoxy primer and two coats of epoxy coating, total DFT 150 microns. Lime tank: Two coats of bitumen paint conforming to IS: 9862, with total DFT 150 microns.
29.06.00	**Walls**
29.06.01	All walls shall be non-load bearing infilled panel walls. All external walls shall be minimum one brick thick masonry wall.
29.06.02	All external and internal walls shall be with minimum one brick masonry (230 or 250 mm) including toilet walls. Toilet partition low height walls shall be minimum half brick masonry.
29.06.03	For all air conditioned areas/ rooms, wherever metal cladding is envisaged as cladding material, additional brick masonry wall (230m thick) shall also be provided in

CLAUSE NO.	TECHNICAL REQUIREMENTS
	addition to metal cladding for effective air conditioning. This brick wall shall be plastered & painted as specified elsewhere in the specification.
29.06.04	RCC transoms and mullions of size 115x115mm with suitable reinforcement shall be provided wherever necessary to reinforce the brickwork.
29.06.05	50 mm thick DPC in Cement concrete (M-20) with water proofing compound followed by two layers of bitumen coating 85/ 25 grade as per IS: 702 @ 1.7 kg/ sq.m. shall be provided at plinth level before starting the masonry work.
29.06.06	The bricks shall be laid with cement mortar (1:6) for one brick thick walls and (1:4) for half brick thick walls IS: 1905, IS: 2212 and SP -- 20 shall be followed for brick work design and construction.
29.07.00	**Plastering**
29.07.01	External (rough) surface of walls shall be plastered with 18 mm thick cement plaster, consisting first (base) layer of 12 mm thick plaster in cement sand mortar (1:6) and second (finishing) layer of 6 mm thick plaster in cement sand mortar (1:4). The internal (smooth) surface of walls shall have 12 mm thick plaster in cement sand mortar (1:6). All external / internal RCC surfaces including RCC parapet walls shall be provided with minimum 12mm thick plaster in cement sand mortar (1:4) except walls of underground structures like cable trenches / valve pits etc.
29.07.02	All exposed faces of R.C.C. walls of structures, buildings and facilities shall have minimum 12 mm thick cement sand plaster 1:6.
29.07.03	All RCC ceilings (except areas provided with false ceilings and cable vault ceiling) shall be provided with 6 mm thick cement sand plaster 1:4.
29.07.04	All plastering work shall conform to IS: 1661.
29.08.00	**Painting**
29.08.01	All painting on masonry or concrete surface shall preferably be applied by roller. If Applied by brush then same shall be finished off with roller.
29.08.02	All paints shall be of approved make including chemical resistant chlorinated rubber paint.
29.08.03	Minimum two finishing coats of paint shall be applied over a coat of primer.
29.08.04	The thinner shall not be used with textured paint (Sandtex Matt or equivalent) finish.
29.09.00	**Internal Finish** All Air conditioned areas shall have 2mm of polymer based water resistant putty (wall putty) to given an even and smooth surface.
29.09.01	Acrylic emulsion paint shall be as per IS: 5411 (Part - 1). Acrylic distemper shall be as per IS: 428. Air - conditioned areas shall be applied with minimum 2 coats of acrylic emulsion paint. All other areas shall be applied with minimum 2 coats of Acrylic distemper.
29.09.02	Toilet, Pantry / Kitchen areas shall have dado with Designer ceramic tiles, 300x200mw (matt finish) upto 2.2 m height and shall match with floor finish. Above dado, Acrylic distemper shall be applied.

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29.09.03	Areas coming in contact with chlorine fumes or acid / alkali shall have two coats of acid / alkali resistant chlorinated rubber paint over suitable primer on walls above dado & ceiling. The paint shall be of approved colour shade and make.
29.10.00	**External Wall Finish** One pack, ready mix and ready to use, resin / polymer bonded granular textured coating finish of 2.5 mm (natural coloured graded stone chips), of approved colour, and shade for all types of plastered and / or exposed concrete surface, in all kinds of works, at all levels, including preparation of surface, preparation of working drawing, labour, material, equipment, handling, transportation, mixing, laying, applying finishing, testing, curing, making grooves, scaffolding, staging, etc., all complete, as per specifications, drawings and instructions of the Engineer-in-charge. Toe wall of chain link fencing shall be provided with two coats of Acrylic Smooth Exterior Paint The finish shall be of approved colour shade and make.
29.11.00	**Ceiling Finish** Ceiling shall have min. two (2) coats of Acrylic distemper except AC areas & Battery room.
29.11.01	For painting on concrete, masonry and plastered & surface, IS: 2395 shall be followed. For painting on steel work and ferrous metals, IS: 1477 shall be followed.
29.11.02	Fire resistant transparent paint (confirming to IS: 162) shall be provided on all wood work, over French police or flat oil paint. French polish shall confirm to IS : 348. Flat oil paint shall confirm to IS: 1237.
29.12.00	**Doors, Windows, Ventilators, Louvers, Rolling Shutters & Glazing**
29.12.01	Adequate Doors, Windows, Louvers and Ventilators shall be provided for proper lighting and ventilation of all buildings. The area of windows shall be at least 10% of the floor area of the respective building. In addition to the above, wherever room height is more than 3.5 m, a band of ventilators of 600 mm height (minimum) shall be provided at the top.
29.12.02	Unless specified all doors, of air conditioned areas, entrance lobby of all buildings shall have electro colour coated (anodised) aluminium frame work with glazing. Windows, ventilators & partitions of all buildings shall have electro colour coated (anodised) aluminium frame work with glazing. All doors of toilet, kitchen, pantry & store areas shall be of factory made pre - laminated solid core flush door shutters, as per IS: 2202 (Part-II) with pressed steel door frame. Control room shall have Aluminium glazed door & partitions. All other doors (unless otherwise specified) shall be of steel.
29.12.03	All steel doors shall consist of double plate flush door shutters. The door shutter shall be 45 mm thick with two outer sheets of 18 G rigidly connected with continuous vertical 20 G stiffeners at the rate of 150 mm centre to centre. Side, top and bottom edges of shutters shall be reinforced by continuous pressed steel channel with minimum 18 G. The door shall be sound deadened by filling the inside void with mineral wool. Doors shall be complete with all hardware and fixtures like door closer, tower bolts, handles, stoppers, aldrops, etc.

CLAUSE NO.	TECHNICAL REQUIREMENTS
29.12.04	Wherever functionally required, rolling shutters of suitable size approved by the Owner, with suitable operating arrangement manual/ electric shall be provided to facilitate smooth operations. Rolling shutters shall conform to IS: 6248.
29.12.05	All windows and ventilators at ground floor level shall be provided with suitable anodised aluminum grill.
29.12.06	Fire proof doors with panic devices shall be provided at all fire exit points as per the requirements. However minimum Fire rating shall be 2 hours. These doors shall be double cover plated type with mineral wool insulation.
29.12.07	Hollow excluded Section of minimum 2 mm wall thickness as manufactured by INDAL, Jindal, Hindalco or equivalent shall be used for all Aluminium doors, windows, ventilators and Partitions.
29.12.08	The doors, Windows & ventilators frame shall be of suitable size & thickness for fixing the glazing. The Glazing thickness shall be minimum 6 mm thk clear toughened glass for all glazed doors, windows, ventilators & partitions. Windows in air conditioned areas shall be provided with 24mm thick hermetically sealed composite double glazing.
29.12.09	Doors and windows on external walls shall be provided with sunshade over the openings with width 600 mm more than the opening width. The projection from the finished face of the wall for sunshade shall generally be 450 mm over window openings, 750 mm over door openings and 900 over Rolling shutters, or as decided and approved by the Engineer.
29.12.10	Float glass or flat transparent sheet glass shall conform to IS: 2835.
29.12.11	All glazing work shall conform to IS: 3548.
29.12.12	Windows in conveyor gallery shall be provided with welded wire fabric of 1.6mm thick wire as per IS: 4948 and 12mm x 30mm mesh size.
30.00.00	**WATER SUPPLY, DRAINAGE AND SANITATION**
30.01.00	Polyethylene water storage tank conforming to IS: 12701 shall be provided (for the use of toilet, pantry and kitchen) over the roof, with adequate capacity depending on the number of users and 8 hours requirement complete with all fittings including float valve, stop cock etc. The capacity of tank shall be calculated minimum 500 liters, per toilet, pantry and kitchen
30.02.00	Galvanised MS pipe of medium class conforming to IS: 1239 shall be used for internal piping works for potable water supply.
30.03.00	Sand C.I. pipes with lead joints conforming to IS: 1729 shall be used for sanitary works above ground level.
30.04.00	The facilities provided in the toilet block shall depend on the number of users. However, minimum facilities to be provided shall be as stipulated below. IS: 1172 shall be followed for working out the basic requirements for water supply, drainage and sanitation. In addition, IS: 2064 and IS: 2065 shall be also be followed.
30.05.00	Each toilet block shall have the following minimum facilities. Unless specified all the fittings shall be of chromium plated brass (fancy type). The common toilet area shall have finished floor level at 15 mm below the finished floor level of surrounding area. Following minimum fittings & fixtures together with associated plumbing works shall be provided as specified below.

Sl. No.	Type of Fitting / Fixtures	Gents Toilet
i)	1 no wall mounted coloured glazed vitreous china European water closet with flush valve.	1 No.
ii)	Coloured glazed vitreous china flat back lipped urinals with photo voltaic controlled automatic flushing system including all requisite fittings and fixtures	1
Iii)	Wash Basin (oval shape) with photo voltaic control system and all requisite fittings and fixtures to be fixed on concrete platform finished with 18mm thick first grade polished granite stone	1 No.
iv)	Wall to wall mirror minimum 450 mm high (minimum 6mm thick float glass) including all fittings	1 No.
v)	Stainless steel Towel Rail 600mm Long x 20 mm dia.	1 No.
vi)	Stainless steel Liquid soap holder cum dispenser with requisite fittings.	1 No.
vii)	Overhead Drinking water storage tank (Minimum 500 Litres capacity)- High density polyethylene (cylindrical/vertical) molded seamless type.	1
viii)	Overhead Service water storage tank (Minimum 500 Litres capacity)- High density polyethylene (cylindrical/vertical) molded seamless type	1 No.

One No. drinking water connection with C.P. brass valve for fixing water cooler by Owner.

Required plumbing work from Owner's service water terminal point to the service water tank and from tank to the toilet accessories mentioned above.

Required plumbing work from Owner's potable water terminal point to the drinking water tank and from tank up to the water coolers.

Janitor room. Adequate space shall be provided.

Provision for installation of water cooler.

30.06.00 All structures, buildings, facilities, liquid storage tanks shall be provided with peripheral surface brick drains of all around periphery and suitably connected to nearest Owner's drain. Overflow and drains from storage tanks shall be laid to and suitably connected to Owner's open surface drains.

30.07.00 The sewerage and waste water disposal system shall consist of providing all associated plumbing and underground pipe works together with all fittings and fixtures and inclusive of ancillary works such as connections, manholes and inspection chambers, including connection to Owner's nearest main sewer line or as directed by Engineer. If required, R.C.C. septic tank and soak pit of required capacity shall be provided by the Bidder.

30.08.00 Miscellaneous Architectural Items

(a.) In all buildings suitable arrangement with provision of floor traps for draining the water collected from leakage, floor washing, fire fighting etc. shall be provided on all floors which shall be connected to rain water down comers.

(b.) Wherever required minimum 1000 high hand railing with 32 NB M.S. pipes medium class as per IS : 1239 shall be provided, with toe & knee rail and toe guard plate, around all floor / roof openings, around periphery of Neutralisation Pit, projections of balconies, walkways, platforms, steel staircase etc.

(c.) However for RCC staircases in structures, buildings and facilities, railings with 20 mm square MS bar balustrades with suitable anti corrosive paint of approved colour MS flats for knee & toe guard with 50mm Ø NB MS pipe hand rail at top shall be provided.

(d.) All air conditioned areas / common corridors shall be provided with false ceiling constructed from 15 mm mineral Fibre Board in tile form of 600x600mm with supporting system as per manufacture guidelines. 50 mm thick mineral wool insulation (conforming to IS : 8183) shall be provided with as under deck insulation). Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, Air conditioning ducts etc. Minimum headroom below false ceiling shall be 3.0 m.

(e.) Under - deck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab of air - conditioned areas depending upon the functional / air - conditioning requirements. The under - deck insulation shall consist of 50 mm thick mineral wool insulation conforming to IS : 8183 backed with 0.05 mm thick aluminium foil & 24 G x 25 mm mesh wire netting and shall be fixed to ceiling with 24 G wire ties and suitable fixing arrangements.

(f.) Parapets, chajjas, window / door heads, architectural facias, fins etc., shall be provided with drip course in cement mortar (1 : 3).

(g.) 150mm thick fillets at junction of roof slab / chajja slab and parapet / vertical walls shall be provided with cast - in - situ cement concrete 1 : 2 : 4 nominal mix, followed by 12 mm thick cement sand plaster (1 : 4).

(h.) Suitable provision shall be made for fixing of ceiling fans in office areas of different structures, buildings and facilities.

31.00.00 CORROSION PROTECTION

31.01.00 GENERAL

(a) All Steel structures shall be provided with painting as given in the specification. Further, painting system shall also meet the requirements of Corrosivity category C3 (durability High) as per ISO 12944.

Painting system for steel surfaces embedded in Concrete is given separately.

(b) All Painting shall be done as per technical specification. Painting scheme shall be submitted by the bidder for approval of employer.

(c) All steel structures shall be designed by following basic design criteria in ISO 12944 Part 3. However, where it is not feasible to follow the design criteria given in ISO 12944 Part 3 where the steel surface are inaccessible for application of protective coating, corrosion allowance of 1.5 mm shall be kept in thickness(over the design thickness) of structural steel members.

d) Painting scheme shall be resubmitted by the Bidder for approval of employer.

31.02.00 PAINTING OF STEEL SURFACES EMBEDDED IN CONCRETE:

CLAUSE NO.	TECHNICAL REQUIREMENTS
	a) For the portion of Steel surfaces embedded in Concrete, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of Chlorinated Rubber based Zinc Phosphate Primer of Minimum 50 Micron Dry Film Thickness (DFT). b) All threaded and other surfaces of foundation bolts and its materials, insulation pins, Anchor channels, sleeves, etc. shall be coated with temporary rust preventive fluid and during execution of civil works, the dried film of coating shall be removed using organic solvents.
31.03.00	PAINTING OF STEEL SURFACES (OTHER THAN THOSE EMBEDDED IN CONCRETE) a) All steel surfaces shall be provided with two component moisture curing zinc (ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% ±2%) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2 ½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust composition and properties shall be Type-II as per ASTM D520-00. b) Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% ±2%) of minimum 100 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique. c) Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer. Notes: 1. For Primer, high quality surface preparation is necessary and good amount of moisture is required for proper curing. Below 70 % relative humidity, curing time may go up to 7 days or more. In such a case additional water sprinkling may be ensured for completion of curing. Additionally Inorganic zinc silicate cannot be recoated; even with itself. Typically it should be used when coating bare steel surface for first time. 2. The most frequent problem associated when top coating Primer is bubbling/pin holing especially with non-weathered zinc silicate coatings. To a great extent, this bubbling of finish paint can be eliminated by applying a mist coat of intermediate/topcoat as the first pass of the product, allow the bubbles to subside and then apply a full coat, as required. 3. In case top coating of zinc silicate with epoxy/polyurethane coatings, is expected to be delayed, it is advisable to use a suitable tie coat to avoid formation of white rust. However, if white rust forms then clean the surface with high pressure water, dry and apply the subsequent coats as required. 4. Touch up paintings on damaged areas: Surface preparation by manual tools, wire brush/ emery paper etc. Minimum 6 inches peripheral area, adjoining to damaged area to be covered. If metal surface is exposed, it is to be painted

CLAUSE NO.	TECHNICAL REQUIREMENTS
	with Zinc rich epoxy (70 micron) or suitable primer with existing paint scheme. If primer is intact, intermediate & top coat to be done with specified DFT in scheme.
31.04.00	**COATING FOR MILD STEEL PARTS IN CONTACT WITH WATER.**
	a) All mild Steel parts coming in contact with water or water vapour shall be hot dip galvanised. The Minimum Coating of Zinc shall be 610 Gms / Sq. M. for galvanised Structures and shall comply with IS: 4759 and other relevant Codes. Galvanising shall be checked and tested in accordance with IS: 2629. b) The galvanising shall be followed by the application of an etching Primer and dipping in black bitumen in accordance with BS: 3416, unless otherwise specified.
31.05.00	**Gratings**
	All gratings shall be blast cleaned to Sa 2 ½ finish or cleaned by acid pickling as per ISO 8501-1 and shall be hot dip galvanized at the rate of 610 Gms / Sq. M.
31.06.00	**Hand Railings and Ladders**
	All Mild steel handrails and ladders shall be galvanised at the rate of 610 Gms / Sq. as per IS: 4736. However, Stainless steel handrails shall be provided as specified in General Architectural Specification clause 9.0.0.
31.07.00	**Sea Worthiness**
	All Steel Sections and fabricated Structures, which are required to be transported on sea, shall be provided with anti corrosive Paint before shipment to take care of sea worthiness.
31.08.00	**For Reinforced Concrete Work.**
	i) The protection for concrete sub-structure shall be provided based on aggressiveness of the soil, chemical analysis of soil/sub-soil water and presence of harmful chemicals/salts. ii) The protection to super structure shall depend on exposure condition and degree of atmospheric corrosion. This shall require use of dense and durable concrete, control of water cement ratio, increase in clear cover, use of special type of cement and reinforcement, etc., coating of concrete surface, etc., Bidder shall furnish the details of corrosion protection measures.
32.00.00	**Miscellaneous**
32.01.00	Ordinary form work shall be used in roofs and floor slabs in transfer houses, footings, pedestals, cable trenches, pits etc., Plywood form work shall be used for all over ground exposed work like columns, beams, floors and ceilings in control room and M. C. C. buildings.
32.02.00	Monorail girders and fixtures shall be provided for monorails at the locations as required and as described elsewhere in these specifications or drawings. Monorail openings in the walls shall be provided with steel frame doors preferably sliding type or otherwise open able inside, access platforms and ladders.

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32.03.00	Steel frame around openings in roof and on external walls for mounting of exhaust fans shall be provided.
32.04.00	Ready mix non - shrink cementitious grout of reputed manufacturer as approved by the Employer shall be used for grouting of block outs and foundation bolts, underpinning of base plates and machine bases. Crushing strength of grout shall be one grade higher than the foundation concrete. Minimum crushing strength shall be 30 N / mm^2 unless higher strength requirement is specified by the equipment supplier or the grout manufacturers.
32.05.00	The bottom of steel in case of cable / pipe galleries and trestles shall be generally 3m above the ground except for rail / road crossing where it shall be 8m above the rail top / road crest/ground. Further in bunker areas it shall be 8 m above the ground.
32.06.00	Polysulphide Sealing Compound shall be two-part polysulphide sealant and shall be from approved manufacturer, conforming to IS : 12118. Materials shall consist of polysulphide polymer and a curing agent. Gun grade material shall be used unless otherwise specified. The application of the sealant shall be strictly followed as per manufacturer's guidelines.
33.00.00	**SHOTCRETING**
33.01.00	**General Requirements**
33.01.01	Generally, shotcreting shall be done in accordance with IS : 9012.
33.01.02	Reinforcement for shotcreting shall be as detailed below, unless specified otherwise. Reinforcement in one direction consisting of 6 mm M. S. bars at 750 mm c / c shall be connected to the lugs for fastening of the wire fabric. This shall be used in case of 50 mm or above thick shotcreting.
33.01.03	Wire fabric conforming to IS : 1566 shall be used as reinforcement and shall consist of wire, 3 mm diameter, spaced 50 mm both ways and shall be electrically cross welded. Wire fabric shall be securely tied to 6 mm bars for 50 mm thickness. Adjacent sheet of wire fabric shall be lapped at least 100 mm and tied.
33.01.04	Clear cover to reinforcement mesh shall not be less than 15 mm.
33.01.05	Minimum thickness of shotcreting shall be 50 mm. for abrasion resistant work and 25 mm for ordinary surface protection work.
33.02.00	**Material** Generally, the materials shall be in accordance with aggregates specification given hereunder.
33.02.01	Fine aggregate shall consist of natural sand or crushed stone from a known source and shall be strong, hard, coarse, sharp, chemically inert, clean and free from any coating. It shall be free from clay, coal or coal residue, organic or any other impurities that may impair the strength or durability of the concrete and shall conform to IS : 383.

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33.02.02	Fine aggregate (Sand) shall be well graded and particles shall range in size within the following limits. The Engineer, may approved the use of any other grading as per requirement or as per IS : 9012.
33.02.03	The fineness modulus shall be preferably between 2.5 and 3.3. Any other value can be used, with prior approval of the Engineer.
33.03.00	**Application**
33.03.01	After the placement of reinforcement and / or welded mesh and not more than six hours prior to the application of shotcrete, the surface shall be thoroughly cleaned of all loose materials and dirt. The Contractor shall properly prepare the surfaces, reinforcement and / or welded mesh to receive the shotcrete. Cleaned surfaces shall be wetted not more than hour prior to shotcreting.
33.03.02	The mix as placed on surface shall be one part cement to three parts approved sand by mass. Cement and sand shall be dry mixed; not water shall be added after mixing and before using in the gun. The quantity of water when added shall be only that which is sufficient to hydrate the cement. For average atmospheric conditions, the water cement ratio for shotcrete in place shall be between 0.35 and 0.5 by mass. Suitable admixture shall be used wherever required.
33.03.03	A uniform pressure of not less than 3 Kg/cm^2 at the nozzle shall be maintained. Necessary adjustments shall be made to ensure this pressure, taking into account the length of hose and height of the place to be shotcreted, above location of the machine.
33.03.04	The application shall proceed in an upward direction. Beams, stiffeners and intermediate walls, if any, shall be wrapped with wire fabric and completely covered with shotcreting. All rebound shall be removed from the area of application as the work progresses and such rebound material shall not be reused.
33.03.05	As soon as the freshly shotcreted surface shows the first dry patches, a fine spray of water shall be applied to keep too moist. After the surface has hardened, it shall be kept continuously moist for minimum seven days. If there is extreme heat, especially when accompanied by hot winds, the shotcreted surface, immediately upon completion, shall be covered with burlap or similar covering, which must be kept continuously moist for 14 days after shotcreting. The temperature of the lining shall not be permitted to exceed 38^0C during placing of concrete.
34.00.00	**VIBRATION ISOLATION SYSTEM** These specifications are meant for the design, supply and erection of vibration isolation system for supporting crushers.
34.01.00	**Supporting Arrangement**
34.01.01	**For Crushers:** The crushers shall be supported on vibration isolation system consisting of steel helical springs and viscous dampers. The supporting arrangement for each crusher shall consist of an R. C. C. deck supported on steel helical spring units and viscous

damper units which in turn shall be supported on girders. The girders shall be an integral part of the crusher house building.

The part of the structure consisting of the R. C. C. deck, springs and viscous dampers shall hitherto be referred to as “spring supported foundation”. The part of the structure, which is below the spring shall hitherto be called “supporting structure”.

34.01.02 The Contractor should do the Engineering / design, supply and erection of vibration isolation system consisting of steel helical spring units and viscous dampers supporting the top deck which in turn would support the crushers. The vibrations isolation system supplied shall be of a proven make. The Contractor or his sub - contractor who designs and supplies the system should have designed, supplied and installed such systems for not less than five machines of speeds and unbalance forces comparable to the machine proposed by the vendor. The vibration isolation systems installed by the contractor or his sub - contractor in such machines should have been working satisfactorily for at least five years.

34.02.00 **Scope of Work**

34.02.01 Scope of work shall include the following :

(a.) Engineering

(1.) Design of the vibration isolation system using steel helical springs and viscous dampers to support an R. C. C. top deck supporting the equipment. This includes the static and dynamic analysis of the vibration isolation system with the R. C. C. top deck and the equipment.

(2.) Structural design of the R. C. C. top deck including preparation of General Arrangement drawings, detailed reinforcement drawings, bar - bending schedules etc.

(3.) Calculation of loads on the structure supporting the springs and viscous dampers, their points of application and the stiffness requirements of the supporting structure.

(4.) Drawings showing embedments and their locations and details on the R. C. C. top deck.

(5.) Drawings showing blockouts, recesses etc. on the top deck.

(6.) Design of the supporting structure, including preparation of detailed drawings and bill of materials.

(b.) Supply including packing and transportation to site

(1.) Steel helical spring units and viscous dampers, including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads etc.

(2.) Frame (s) for pre-stressing of spring elements.

(3.) Suitable hydraulic jacks system including electric pumps, high pressure tubes etc. required for the installation, alignment etc. of the spring units, two extra hydraulic jacks, one hand operated pump and spares for the hydraulic jack system as required.

(c.) Erection and Commissioning

(1.) Complete erection and commissioning of the vibration isolation system including :

(2.) Pre-stressing of spring elements, placing of spring elements in position, checking clearances on the shuttering of the R. C. C. top deck, construction of the supporting structure and the R. C. C. top deck, releasing to pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

(3.) The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

(4.) This part of the specifications is for vibration isolation system. For the construction of the supporting structure for the crusher and the top deck, the relevant parts of the specification should be referred to.

(d.) Documentation

(1.) Submission of detailed design calculation, analysis (static and dynamic) and drawings for Employer's acceptance and approval.

(2.) Furnishing methodology of providing shuttering and its removal as well as concreting of deck slab, installation of springs and dampers and the sequence of operation.

(3.) Furnishing installation and maintenance manual indicating equipment, procedure etc., necessary for installation, maintenance of vibration isolation system.

(4.) Furnishing a check list for confirming the readiness of the civil fronts for the installation of vibration isolation system and equipment required at each stage installation.

(5.) Bill of materials of various elements such as springs, visco-dampers, with their rating, stiffness etc., included in supply.

(6.) Detailed specifications of the vibration isolation system and various items included in the supply and the standard (local or international) to which they conform.

(7.) Proposed erection strategy of the entire system.

34.03.00 Design Requirements for Crusher Foundation

34.03.01 Dynamic Analysis

Detailed dynamic analysis shall be done for the top deck together with springs and dampers and the natural frequencies and amplitudes of vibration shall be determined. A mathematical model of the top deck shall be formulated with three - dimensional beam / plate finite elements for the purpose of analysis with the spring idealised with vertical and horizontal stiffnesses. The mass of the machine together with that of the top deck shall be considered for the analysis.

Natural frequencies upto at least 10 % above the operating speed shall be determined and these frequencies shall be checked against the design criteria.

Forced response dynamic analysis shall be carried out for the operating condition unbalance forces using a sinusoidal forcing function. Unbalance forces as given by this specifications shall be used for his purpose. The amplitudes shall be checked against the design criteria. The dynamic forces from this analysis shall be used for structural design with a suitable fatigue factor.

34.03.02 Isolation Efficiency

The vibration isolation system shall be designed for about 90 % isolation efficiency.

34.03.03 De-coupling

A ratio of the least 10 (ten) shall be ensured between the stiffness of the supporting structure and the stiffness of the spring system in the vertical direction to achieve de-coupling between the two (the stiffness of the spring system being lower). This ensures that dynamic analysis of the supporting structure need not be carried out.

34.03.04 Frequency Criteria

The frequency criterion has already been laid down implicitly by the isolation efficiency criteria and de-coupling required.

The first bending mode frequency of the top deck shall be at least 20 % above the operating speed.

34.03.05 Unbalance Forces for Crushers

Unbalance forces arising out of all the following cases shall be considered for checking the design and amplitudes.

(a.) Balance quality grade Q 40 as per VDI 2060 - 1966.

(b.) One hammer broken condition. The missing hammer shall be assumed to be closest to the crusher non - drive end of the crusher.

(c.) Three hammers broken condition. All the three hammers broken shall be assumed to be from the same suspension bar and located at the non - drive end of the crusher.

34.03.06 Amplitude Criteria for Crushers

The calculated amplitudes (mean to peak values) shall not exceed following limits under the specified conditions.

1) Operating speed of 750 RPM

(a.) 150 microns for an unbalance force arising out of balance quality grade Q 40 as per VDI 2060 - 1966.

(b.) 300 microns in case of a one hammer broken condition.

(c.) Amplitudes need not be checked for a three hammer broken condition.

2) Operating speed of 450 RPM

(a.) 200 microns for an imbalance force arising out of balance quality grade Q-40 as per VDI -2060-1966.

(b.) 400 microns in case of a one hammers broken condition.

(c.) Amplitude need not be checked for a three hammer broken condition.

For intermediate operating speed between 450 to 750 RPM the amplitude limits can be linearly interpolated.

The amplitude limits mentioned above are in both vertical and horizontal directions. The amplitudes shall be calculated at critical points on the top surface of the R. C. C. deck. The amplitudes shall be checked for the most unfavorable superposition of modes in any direction. However, phase difference between the maximum amplitude occurring in different directions due to the rotating vetor may be considered while superimposing the modes.

34.03.07 Unbalance force and Amplitude Criteria

The unbalance forces and amplitude criteria shall be as per the equipment manufacturer's recommendations or as per VDI 2060/ VDI 2056, whichever is more stringent.

34.03.08 Transient Resonance

Transient resonance, which may occur during the start - up or coasting down condition of the crusher, shall be checked, and the amplitudes in such a condition should not exceed one - and - half times those at operating speed for each design condition.

34.04.00 Strength Criteria

The following criteria shall apply for the design of top deck :

(a.) Dead loads, live loads, Seismic loads and dynamic loads shall be considered for the design. The most unfavorable combination shall considered for design.

(b.) Seismic loads shall be assumed to act together with dynamic loads for a one millimeter eccentricity in the rotor. However, seismic loads and dynamic loads arising out of hammer breakage need not be considered together

(c.) Fatigue shall be considered while designing for dynamic forces. A fatigue factor of 2.0 shall be used on all dynamic forces to arrive at the equivalent static force for the purpose of design.

(d.) Working stress method shall be used for the design of R. C. C. deck. In survival condition, 10 % overstressing may be permitted.

(e.) The R. C. C. top deck shall be at least of M35 grade of concrete as per IS : 456.

(f.) Fatigue need not be considered for the three hammer broken condition.

(g.) For calculating unbalance forces, the heaviest hammer (plain or toothed) shall be considered.

34.05.00 Approval of Designs and Drawings

All design calculation, drawings and documents shall be in English. All design calculations and drawings shall be submitted to Employer for approval. However, approval of such designs and drawings shall not relieve the contractor of his responsibility regarding the adequacy of the foundation to carry the design forces.

34.06.00 Standards

Latest revisions of the following Codes shall be used for the design of the crusher foundations.

(a.) IS : 456 Code of Practice for Plain and Reinforced concrete.

(b.) IS : 2974 (Part IV) Code of Practice for Design and Construction of Machine Foundations (Part IV) for rotary type machine of low frequency.

(c.) IS : 1893 (Criteria for Earthquake Resistant Design of Structures).

(d.) DIN 4024 Machine Foundations :

Flexible supporting structures for machines with rotating masses.

(e.) DIN 2089

Helical Compression Springs out of round wire and rod; calculation and Design.

(f.) DIN 2096

Helical Compression Springs out of round wire and rod; quality requirements for hot formed compression springs.

(g.) VDI 2056 - Criteria for assessing mechanical vibrations of machines.

(h.) VDI 2060 - Criteria for assessing the state of balance of rotating rigid bodies.not be permitted to exceed 38^{o}C during placing and curing

35.00.00 Packaging and Transportation.

All the equipment shall be suitably protected coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials the limitations from the point of view of availability of railway wagon sizes in India should be taken into account. The contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

36.00.00 Plant Life

The plant shall be designed for a minimum operating life of 30 years under the conditions of operation. Assurance shall be given that plant components are adequate for this lifetime. If there are any exceptional items of the plant on which an assurance of meeting this clause cannot be given, life of such components and the difficulties associated with them shall be stated.

37.00.00 PTFE (Poly Tetra Fluoroethylene) Bearing

The bearing shall be of reputed make and manufacturer as approved by the Engineer, for required vertical load and end displacement/rotation. PTFE bearing shall be sliding against highly polished stainless steel and the coefficient of friction between them shall be less than 0.06 at 55 kg/sq.cm. In order to prevent cold flow in PTFE surface it shall be rigidly bonded by a special high temperature resistance adhesive to the stainless steel substrata. The stainless steel surface that slides against the PTFE is mirror polished. The stainless steel shall be bonded to the top plate by special high strength adhesive. The thickness of stainless steel plate shall be between 1.0 mm to 1.5 mm.

38.00.00 TESTS FOR MATERIAL / WORKMANSHIP

All tests required for all materials, quality of workmanship or any other tests as desired by the Engineer shall be at contractor's cost.

39.00.00 MATERIALS

39.01.00 For Civil, Structural and Architectural works

Employer will not supply any material. All materials including cement, reinforcement steel and structural steel, whatsoever required for execution and completion of the entire scope of work covered under this specification shall be arranged by the contractor at his own cost. All materials procured by the contractor shall meet the quality requirements specified in this specification.

The contractor shall keep sufficient stock of cement and steel at site at any point of time when the work is in progress excluding what has been already incorporated in the works, so that any disruption / delay in availability of these materials during procurement will not affect the progress of work at site. The minimum quantity of such materials in stock at site shall not be less then the Requirement of one (1) month in case of Cement and Requirement of two (2) Consecutive months in case of Steel.

39.02.00 Structural steel

Structural Steel (including embedded Steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall comprise of mild steel, medium strength steel and high tensile steel as specified below.

39.02.01 Mild Steel

a) Rolled sections shall be of grade designation E250, Quality A/BR, Semi-killed/ killed conforming to IS 2062. All steel plates shall be of Grade designation E250, Quality BR (fully killed), conforming to IS 2062 and shall be tested for impact resistance at room temperature. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalised and shall also be 100% ultrasonically tested as per ASTM –A578 level B-S2.

b) Pipes shall conform to IS 1161.

c) Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of minimum Grade Yst 240.

d) Chequered plate shall conform to IS 3502 and shall be minimum 6 mm thick excluding projection. Steel for chequered plate shall conform to grade E250A semi killed of IS: 2062 or equivalent grade conforming to ASTM & BS standards only.

39.02.02 Medium and High Tensile Steel

Rolled Sections and plates shall be of grade designation E350 or higher, Quality B0 (Fully killed), conforming to IS 2062. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalised and shall also be 100% ultrasonically tested as per ASTM –A578 level B-S2.

39.03.00 Fly ash based Portland pozzolona cement conforming to IS: 1489 Part - I shall preferably be used. However, the contractor may use other types of cements conforming to IS: 269, IS: 8112, IS: 12269, & IS: 455.

39.04.00 **Reinforcement steel shall conform to:**

a) Mild steel bars of grade I of IS: 432 Part – I or grade A of IS: 2062.

b) High yield strength deformed TMT steel bars of grade Fe-500 having minimum elongation of 14.5 % or Fe-500D, and conforming to other requirements of IS 1786.

40.00.00 **CODES AND STANDARDS**

All standards, specifications, acts and code of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. Other Indian, foreign Codes and Standards not listed here but referred to elsewhere within this specification shall also be deemed to be part of this list.

In case of conflict between this specification and those (IS standards, codes etc.) referred to herein, the former shall prevail.

Some of the relevant Indian standards, Acts and Codes applicable to this section of the specification are listed below

IS : 383	Specification for coarse and fine aggregates from natural sources for Concrete.
IS : 432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS : 456	Code of practice for plain and reinforced concrete.
IS : 458	Specification for concrete pipes.
IS : 516	Method of test for strength of concrete.
IS : 800	Code of practice for use of structural steel in general building construction.
IS : 814	Specification for covered electrodes for metal arc welding for weld steel.
IS : 816	Code of practice for use of metal arc welding for general construction.
IS : 817	Code of practice for training and testing of metal arc welders.
IS : 875 (Pt. I to V)	Code of practice for design loads other than earthquake) for buildings and structures.
IS : 1038	Steel doors, windows and ventilators.

IS : 1172	Basic requirements for water supply, drainage and sanitation.
IS : 1361	Steel windows for industrial buildings.
IS : 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS : 1892	Code of practice for subsurface investigation for foundation.
IS : 1893	Criteria for earthquake resistant design of structures.
IS : 1904	Code of practice for design and construction of foundations in soils; general requirements.
IS : 1905	Code of practice for structural safety of buildings - Masonry walls.
IS : 1948	Specification for aluminium doors, windows and ventilators.
IS : 2062	Steel for general structural purposes.
IS : 2131	Method of standard penetration test for soils.
IS : 2212	Code of practice for brickwork.
IS : 2645	Specification for Integral cement water proofing compounds.
IS:2720 (Part-II, IV TO VIII, XIV, XXI, XXIII, XXIV, XXVII TO XXIX, XL)	Methods of test for soils - determination for water content etc code of practice for earth work on canals.
IS : 2911	Code of practice for design and construction of pile foundations.
(Part-1/Sec.1)	Driven cast in situ concrete piles.
(Part-1/Sec.2)	Bored cast-in-situ concrete piles.
(Part-IV)	Load test on piles.
IS : 2974 (Part - I TO V)	Code of practice for design and construction of machine foundations.
IS : 3370 (Part I to IV)	Code of practice for concrete structures for the storage of liquids.
IS : 3658	Code of practice for liquid penetrant flaw detection.
IS : 3664	Code of practice for ultra sonic testing by pulse echo method.

IS : 4326	Code of practice for earthquake resistant design and construction of buildings.
IS : 4990	Specification for plywood for concrete shuttering work.
IS : 5624	Specification for foundation bolts.
IS : 7215	Tolerances for fabrication steel structures.
IS : 8112	Specification for 43 grade Ordinary Portland Cement.
IS : 9103	Specification for admixtures for concrete.
IS : 9595	Code of procedure of manual metal arc welding of mild steel.
IS : 10262	Recommended guidelines for concrete mix design.
IS : 13311	Method of non - destructive testing of concrete.
IS : 13755	Dust pressed ceramic tiles with water absorption of 3%, E6% (Group B11a)
ASTM 898 -89	Standard guide for use of high solid content, cold liquid-applied elastomeric water proofing membrane for use with separate wearing course.
AS/NZS 2728	Pre finished / pre painted sheet metal product for interior / exterior building applications – Performance requirements.
AS : 1365	Standards for steel manufacturing.
AS : 1397	A steel sheet & strip – hot – dipped-zinc-coated or Aluminium-Zinc coated.
AS : 3566	Self drilling screws for building and construction industry.
IRC : 37	Guidelines for the design of flexible pavements.
-	Manual on sewerage and sewage treatment (Published by CPH & EEO) As updated.

Indian Explosives Act. 1940 as updated.

Annexure-A

CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT

All structures and equipment shall be designed for seismic forces adopting the site specific seismic information provided in this document and using the other provisions in accordance with IS:1893 (Part 1 to Part 4). Pending finalization of Part 5 of IS:1893, provisions of part 1 shall be read along with the relevant clauses of IS:1893:1984, for embankments.

A site specific seismic study has been conducted for the project site. The peak ground horizontal acceleration for the project site, the site specific acceleration spectral coefficients (in units of gravity acceleration 'g') in the horizontal direction for the various damping values and the multiplying factor (to be used over the spectral coefficients) for evaluating the design acceleration spectra are as given at Appendix-I.

Vertical acceleration spectral values shall be taken as 2/3rd of the corresponding horizontal values.

The site specific design acceleration spectra shall be used in place of the response acceleration spectra, given at figure-2 in IS:1893 (Part 1) and Annex B of IS:1893 (Part 4). The site specific acceleration spectra along with multiplying factors specified in Appendix-I includes the effect of the seismic environment of the site, the importance factor related to the structures and the response reduction factor. Hence, the design spectra do not require any further consideration of the zone factor (Z), the importance factor (I) and response reduction factor (R) as used in the IS:1893 (Part 1 to Part 4).

Damping in Structures

The damping factor (as a percentage of critical damping) to be adopted shall not be more than as indicated below for:

a)	Steel structures	:	2%
b)	**Reinforced Concrete structures**	:	5%
c)	Reinforced Concrete Stacks	:	3%
d)	Steel stacks	:	2%

Method of Analysis

Since most structures in a power plant are irregular in shape and have irregular distribution of mass and stiffness, dynamic analysis for obtaining the design seismic forces shall be carried out using the response spectrum method. The number of vibration modes used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and shall also meet requirements of IS:1893 (Part 1). Modal combination of the peak response quantities shall be performed as per Complete Quadratic Combination (CQC) method or by an acceptable alternative as per IS:1893 (Part 1).

In general, seismic analysis shall be performed for the three orthogonal (two principal horizontal and one vertical) components of earthquake motion. The seismic response from the three components shall be combined as specified in IS:1893 (Part 1).

The spectral acceleration coefficient shall get restricted to the peak spectral value if the fundamental natural period of the structure falls to the left of the peak in the spectral acceleration curve.

For buildings, if the design base shear (V_B) obtained from modal combination is less than the base shear ($\bar{V}_B$) computed using the approximate fundamental period (T_a) given in IS:1893:Part 1 and using site specific acceleration spectra with appropriate multiplying factor, the response quantities (e.g. member forces, displacements, storey forces, storey shears and base reactions) shall be enhanced in the ratio of $\bar{V}_B / V_B$. However, no reduction is permitted if $\bar{V}_B$ is less than V_B.

For regular buildings less than 12m in height, design seismic base shear and its distribution to different floor levels along the height of the building may be carried out as specified under clause 7.5, 7.6 & 7.7 of IS:1893 (Part 1) and using site specific design acceleration spectra. The design horizontal acceleration spectrum value (Ah) shall be computed for the fundamental natural period as per clause 7.6 of IS:1893 (Part 1) using site specific spectral acceleration coefficients with appropriate multiplying factor given in Appendix-I.

Design/Detailing for Ductility for Structures

The site specific design acceleration spectra is a reduced spectra and has an in-built allowance for ductility. Structures shall be engineered and detailed in accordance with relevant Indian/International standards to achieve ductility.

APPENDIX – I

SITE SPECIFIC SEISMIC PARAMETERS FOR DESIGN OF STRUCTURES AND EQUIPMENT

The various site specific seismic parameters for the project site shall be as follows:

1) Peak ground horizontal acceleration : 0.19g

2) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') to obtain the design acceleration spectra

   a) for moment resisting steel frames designed and detailed as per IS:800 and moment resisting RC frames designed and detailed as per IS:456 : 0.067

   b) for braced steel frames designed and detailed as per IS:800 : 0.05

   c) for moment resisting RC frames designed and detailed as per IS:456 and IS:13920 : 0.04

   d) for RCC Chimney :0.133

   e) For Liquid retaining tanks : 0.08

   f) for Steel chimney, Absorber tower : 0.10

   g) for design of structures not covered under 2 (a) to 2 (f) above and under 3 below : 0.067

3) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') for design of equipment and structures where inelastic action is not relevant or not permitted : 0.133

Note: g = Acceleration due to gravity

The horizontal seismic acceleration spectral coefficients are furnished in subsequent pages.

APPENDIX – I

HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS
In units of 'g' for NORTH KARANPURA STPP

Period (Sec)	Damping Factor (as a percentage of critical damping)		
	2%	3%	5%
0.000	1	1	1
0.030	1	1	1
0.040	1.693	1.564	1.418
0.050	2.548	2.213	1.859
0.058	3.344	2.787	2.226
0.059	3.450	2.863	2.273
0.060	3.558	2.938	2.320
0.061	3.667	3.015	2.367
0.062	3.778	3.092	2.414
0.065	4.119	3.328	2.557
0.067	4.366	3.488	2.652
0.070	4.366	3.734	2.797
0.071	4.366	3.772	2.846
0.074	4.366	3.772	2.992
0.075	4.366	3.772	3.042
0.084	4.366	3.772	3.054
0.094	4.366	3.772	3.054
0.104	4.366	3.772	3.054
0.114	4.366	3.772	3.054
0.120	4.366	3.772	3.054
0.121	4.366	3.772	3.054
0.123	4.366	3.772	3.054
0.124	4.366	3.772	3.054
0.126	4.366	3.772	3.054
0.133	4.366	3.772	3.054
0.304	4.366	3.772	3.054
0.310	4.366	3.772	3.054
0.327	4.366	3.772	3.054
0.335	4.366	3.772	3.054
0.352	4.366	3.772	3.054
0.376	4.366	3.772	3.054
0.400	4.366	3.772	3.054
0.450	4.350	3.760	3.042
0.500	3.808	3.454	2.720
0.550	3.462	3.140	2.473
0.601	3.168	2.874	2.263
0.604	3.152	2.859	2.252
0.617	3.086	2.799	2.204
0.622	3.061	2.777	2.186
0.632	3.013	2.733	2.152
0.667	2.855	2.589	2.039

APPENDIX – I

HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS
In units of 'g' for NORTH KARANPURA STPP

Period (Sec)	Damping Factor (as a percentage of critical damping)		
	2%	3%	5%
0.767	2.482	2.252	1.773
0.867	2.196	1.992	1.569
0.967	1.969	1.786	1.406
1.067	1.784	1.619	1.275
1.167	1.632	1.480	1.165
1.267	1.503	1.363	1.073
1.367	1.393	1.263	0.995
1.467	1.298	1.177	0.927
1.567	1.215	1.102	0.868
1.667	1.142	1.036	0.816
1.767	1.078	0.977	0.770
1.867	1.020	0.925	0.728
1.967	0.968	0.878	0.691
2.067	0.921	0.836	0.658
2.167	0.879	0.797	0.628
2.267	0.840	0.762	0.600
2.367	0.804	0.730	0.575
2.467	0.772	0.700	0.551
2.567	0.742	0.673	0.530
2.667	0.714	0.648	0.510
2.767	0.688	0.624	0.492
2.867	0.664	0.602	0.474
2.967	0.642	0.582	0.458
3.067	0.621	0.563	0.443
3.167	0.601	0.545	0.429
3.267	0.583	0.529	0.416
3.367	0.565	0.513	0.404
3.467	0.549	0.498	0.392
3.544	0.537	0.487	0.384
3.559	0.535	0.485	0.382
3.666	0.519	0.471	0.371
3.765	0.506	0.459	0.361
3.865	0.493	0.447	0.352
3.965	0.480	0.436	0.343
4.006	0.475	0.431	0.339
4.017	0.474	0.430	0.339
4.056	0.469	0.426	0.335

ANNEXURE-B

CRITERIA FOR WIND RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT

All structures shall be designed for wind forces in accordance with IS: 875 (Part-3) and as specified in this document. See Annexure – B for site specific information.

Along wind forces shall generally be computed by the Peak (i.e. 3 second gust) Wind Speed method as defined in the standard.

Along wind forces on slender and wind sensitive structures and structural elements shall also be computed, for dynamic effects, using the Gust Factor or Gust Effectiveness Factor method as defined in the standard. The structures shall be designed for the higher of the forces obtained from Gust Factor method and the Peak Wind Speed method.

Analysis for dynamic effects of wind must be undertaken for any structure which has a height to minimum lateral dimension ratio greater than “5” and/or if the fundamental frequency of the structure is less than 1 Hz.

Susceptibility of structures to across-wind forces, galloping, flutter, ovalling etc. should be examined and designed/detailed accordingly following the recommendations of IS:875(Part-3) and other relevant Indian standards.

It should be estimated if size and relative position of other structures are likely to enhance the wind loading on the structure under consideration. Enhancement factor, if necessary, shall suitably be estimated and applied to the wind loading to account for the interference effects.

Damping in Structures

The damping factor (as a percentage of critical damping) to be adopted shall not be more than as indicated below for:

a)	Welded steel structures	1.0%
b)	Bolted steel structures	2.0%
c)	Reinforced concrete structures	1.6%
d)	Steel stacks	As per IS:6533 & CICIND Model Code whichever is more critical.

ANNEXURE-B

SITE SPECIFIC DESIGN PARAMETERS

The various design parameters, as defined in IS: 875 (Part-3), to be adopted for the project site shall be as follows:

a)	The basic wind speed "V_b" at ten metres above the mean ground level	47 metres/second
b)	The risk coefficient "K_1"	1.07
c)	Category of terrain	Category-2

CLAUSE NO.	TECHNICAL REQUIREMENTS
	ANNEXURE-C
1.00.0	**FOUNDATION SYSTEM AND GEOTECHNICAL DATA**
1.01.0	**Soil Data**
	Owner has carried out geotechnical investigation at the project site. Few bore logs, available of vicinity to this area are enclosed at Annexure-III for Bidder's reference. The geotechnical investigation report for nearby areas will be made available for the Bidder's study at the Owner's office, if required. Onus of correct assessment/ interpretation and understanding of the existing subsoil condition / data is on the Bidder. The natural ground reduced levels (RLs) of FGD Area as per topographical survey drawing varies from RL 459.0m to 461.6m. Site levelling & grading had been carried out and achieved finished ground level (FGL) is RL (+) 460.0m i.e. there is maximum filling of 1.0m and maximum cutting of 1.6m in FGD area. However, site levelling in Hopper, Crusher House, Lime & Gypsum storage area etc. shall be done under this package and as per Topographical survey drawing existing ground levels are varying from 461.9m to 465.6m and FGL to be achieved in this area shall be as indicated in GLP. Bidder may refer topographical survey drawing for variation in existing/ natural ground level and FGL. As per borelog data, water table is varying from 1.6m to 3.8m at the time of field investigation and may fluctuate with season.
1.01.01	Since the available soil data is of vicinity, bidder shall carryout his own detailed soil investigation for facilities under this package and shall be as per the scheme approved by Owner**.** The scheme for geotechnical investigation shall be as given at Clause 1.07.00 and shall be approved by Owner before execution. Geotechnical investigation work shall be got executed by the Contractor through the agencies as mentioned in Clause No. 1.07.03. However, no time extension shall be given on account of soil investigation carried out by the Bidder. The geotechnical investigation report shall be prepared with detailed recommendations regarding type of foundation and allowable bearing pressure for various structures/ facilities and other soil parameters. The report shall be submitted for Owner's approval prior to commencement of design of foundation.
1.01.02	The Bidder should note that nothing extra whatsoever on account of variation between soil data collected by Owner and that found by the Bidder during geotechnical investigation by him or during execution of works, shall be payable.
1.01.03	Tank Foundations a) The tanks shall rest on flexible tank pad foundation, resting on sand with concrete ring wall to retain sand. Base of the concrete ring wall shall not rest on the expansive soil, if any. b) Entire loose/ soft soil inside the concrete ring wall shall be removed and shall be filled with sand. Sand for filling shall be clean and well graded conforming to IS 383 with grading Zone I to III. c) Sand shall be spread in layers not exceeding 30cm compacted thickness over the area. Each layer shall be uniformly compacted by mechanical means like plate vibrators, small vibratory rollers, etc to achieve a relative density of not less than 80%.

d) Other requirements of tank foundations shall be as per IS 803 and as specified elsewhere in the specifications.

1.02.00 **Foundation System**

The requirements for the foundation system to be adopted are as given in subsequent clauses. Depending upon the depth of competent strata/stratum, type of structures, functional requirement of facility, extent of cutting / filling, suitable foundation, open or pile shall be adopted with approval of owner.

102.01 General Requirements

a) All structures/equipment shall be supported either on suitable open foundations (isolated, combined, raft) or pile foundations depending on type of structures/facilities, sub-strata, topography etc.

b) The roads, ground floor slabs, trenches, pipe pedestals, channels/drains and staircase foundation with foundation loading intensity less than 4 T / M2 may be supported on open / shallow foundations resting on virgin / controlled compacted filled up soil.

c) No other foundation (other than as mentioned in (b) above) shall rest on the filled up ground / soil.

d) All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian Standards.

e) The water table for design purpose shall be considered at Finished Ground Level.

f) A combination of open and pile foundations shall not be permitted under the same equipment / structure / building.

g) Foundation for equipments on ground floor

For equipments of static weight upto 1.5 T, the equipment may be supported on the ground floor slab by locally thickening the slab. Thickening of the ground floor slab shall be done upto an extent of about 0.6 m beyond the plan area of the equipment on all the sides. Further, the load intensity below the equipment shall be limited to 4T/m2. Other requirements of floor slab and compaction below the floor slab shall be adhered, as specified elsewhere in the specifications.

For equipment of static weight more than 1.5 T, the equipment foundation shall be taken to the founding level or shall be built up with PCC from the level as mentioned in the Table 1. The pedestal of equipment foundation or the foundation Block shall be isolated from the adjoining floor slab by providing bitumen impregnated fiber board of minimum 50 mm thick, conforming to IS: 1838 all around the equipment pedestal for the full depth of the floor slab.

1.02.02 Open Foundations

In case open foundations are adopted, following shall be adhered to.

a) The minimum width of foundation shall be 1.0 m.

b) Minimum depth of foundation shall be 1.0m below Ground Level.

c) It shall be ensured that all foundations of a particular structure/ buildings/ facility shall rest on one bearing stratum.

d) Wherever the intended bearing sub-strata is virgin soil stratum but the actual stratum encountered during foundation excavation consists of filled up soil at founding level, under such cases either the foundation shall be lowered completely into the virgin stratum or the filled up soil upto the virgin layers shall be removed and built up through PCC (1:4:8) up to designed foundation level.

e) During design the Allowable Bearing Pressure shall be adopted after approval of geotechnical investigation report. However, the maximum allowable bearing pressure shall be as per approved geotechnical report and shall be limited to the values as furnished in Table-1.

Table-1

Founding Depth/ Stratum	Net Allowable Bearing Pressure T/m2		
	Isolated and combined footings including raft for 25mm permissible settlement in case of soil and 12mm in case of rocky strata	Isolated and combined footings for 40mm permissible settlement in case of soil and 12mm in case of rocky strata	Rafts (width > 6m) for 75mm permissible settlement in case of soil and 12mm in case of rocky strata
	Width upto 6.0m		
In case of Soil			
2.0m below NGL	10	14	18
3.0m below NGL	14	18	24
In case of rocky strata			
1m into highly weathered rock*	35	35	35
2m into highly weathered rock*	45	45	45

* Highly weathered sandstone with shale bands/highly weathered fine grained fractured rock, stratum is with SPT 'N' > 100 (Refusal) and core recovery (CR) around 20% or more.

For NGL & FGL of the proposed area GLP along with topographical survey drawing may be referred.

In case any loose/soft pockets in rocky strata is encountered at founding level, the same shall be removed completely upto the hard strata and filled up with PCC (1:4:8).

f) For open foundations, the total permissible settlement shall be governed by IS: 1904 / IS: 13063 and from functional requirements whichever is more stringent. However, total settlement shall be restricted to the following:

Isolated & Raft (Mill foundations/ Machine Foundations) resting on soil	25 mm
Isolated (other than Mill foundations/ Machine Foundations) resting on soil	40 mm
Raft (other than Mill foundations/ Machine Foundations) resting on soil	75 mm
Foundations in Weathered rock / rock	12 mm

Incase pile foundations are to be adopted the requirements under para "Pile Foundations" shall be adhered to.

1.02.03 Pile Foundations –

In case piles are adopted, following shall be adhered to :

i) The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911. Pile boring shall be done using Rotary Hydraulic Rigs. Two stage flushing of pile bore shall be ensured by airlift technique duly approved by the Employer.

If required, temporary or permanent MS liner may be provided for piling.

ii) The minimum diameter of pile shall be 600 mm. The allowable load capacity of the pile in different modes (vertical compression, lateral and pullout) shall be as per approved geotechnical report & shall be limited to the values given below:

Pile	Dia. (mm)	Vertical compression capacity (T)
Bored cast-in-situ pile	600	140
	760	250

The pile shall be socketed into rock strata with minimum socket length of 5 times the diameter of pile below the start of socketing horizon. Socketing horizon shall be considered as the zone wherein average core recovery is atleast than 30 %.

The uplift and lateral load capacity shall be respectively restricted to 35% and 5% of the allowable load capacity in vertical compression.

However, the pile capacities to be adopted shall be the least of the estimated design values and that obtained from the initial pile load tests.

iii) Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.

iv) The contractor shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, pile load test arrangement, locations of initial test piles etc.) for Engineer's approval.

v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical

Lateral Minimum of 2 Nos. in each mode.

Uplift

vii) The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of vertical compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).

viii) Load test shall be conducted at pile Cut-off Level (COL). If the water table is above the COL the test pit shall be kept dry throughout the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.

ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :

i) Vertical : 0.5% of the total number of piles provided.

ii) Lateral : 0.5% of the total number of piles provided.

x) The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.

xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.

xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

xiii) The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge with concrete blocks.

xiv) Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency to be approved by Engineering department of Owner. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.

xv) High Strain Dynamic Load Test may be carried out for routine load testing of working piles. However, at least two numbers of static routine vertical load tests shall be carried out on pile on which high strain dynamic load test has already been carried out for establishing the correlation between the two tests. In case of discrepancy if any between dynamic and static vertical load tests, then additional static routine vertical load tests shall be conducted as decided by the Engineer and the results of static routine vertical load shall prevail. Number of routine vertical pile load tests as per clause 7.02.03 (ix) shall be total of static routine vertical load test and high strain dynamic load tests.

The procedure to carry out the test shall be submitted to the Engineer. The test and equipment shall conform to ASTM D4945-00. The test shall be conducted by an experienced independent test agency approved by the owner. Field data shall be submitted to the site engineer and shall include force velocity curves, pile capacity, simulated static load test curve, net and total pile displacement, pile integrity. A (Case pile wave analysis) CAPWAP or equivalent software analysis shall be conducted on the field data for correct capacity estimation and to evaluate end bearing and skin friction components of the pile.

xvi) From load considerations, single pile may be used under a column/tower. In that case, pile shall be connected with tie beams at pile cut off level in both directions.

xvii) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.

xviii) Reinforcement for job piles shall be designed as following:

(a) Compression + bending piles: For these piles, the allowable safe pile capacities in compression and bending shall be considered.

(b) Tension + bending piles: For these piles, the actual pile forces to be considered. However, maximum 3 types of combinations for varying percentage of tension capacity + bending case may be designed & adopted by contractor for the entire scope of work under this package.

1.03.00 Special Requirements

1.03.01 Details of treatment for foundations / underground structures required to counteract soil / water chemical environment shall be as per detailed geotechnical investigation to be carried out by contractor. Contractor shall carry out chemical analysis during detailed geotechnical investigation and required treatment shall be provided accordingly.

1.04.00 Excavation, Filling and Dewatering

1.04.01 For excavation works, comprehensive dewatering with well point or deep wells arrangement, if required, shall be adopted. Scheme for dewatering and design with all computations and back up data for dewatering shall be submitted for the owner's information. The water table shall be maintained at 0.5m below the founding depth.

1.04.02 Excavation for shallow foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil or any loose pockets are encountered at founding level during excavation the same shall be removed and compensated by PCC M7.5. The final layer of about 300 mm thickness above the founding level shall be excavated by suitable means, so as to avoid disturbance to founding stratum.

1.04.03 Backfilling around foundations, pipes, trenches, sumps, pits, plinths, etc. shall be carried out with approved material in layers not exceeding 300 mm compacted thickness (higher thickness of layers upto 500mm with heavy mechanical compacting equipment) and each layer shall be compacted to 90% of standard proctor density for cohesive soils and to 80% of relative density for non cohesive soils

Rock pieces having size less than 150 mm and interstices filled with soil may be used for backfilling around foundation, plinths etc. and shall be compacted to minimum of 85% of original stack of material after filling the interstices.

1.04.04 Founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches / channels.

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.04.05	CBR tests for pavement/road design shall be carried out by the Contractor after earth filling (if applicable) has been completed upto the formation level.
1.04.06	**THE CONTRACTOR SHALL TAKE ALL NECESSARY MEASURES DURING EXCAVATION TO PREVENT THE HAZARDS OF FALLING OR SLIDING OF MATERIAL OR ARTICLE FROM ANY BANK OR SIDE OF SUCH EXCAVATION WHICH IS MORE THAN ONE AND A HALF METER ABOVE THE FOOTING BY PROVIDING ADEQUATE PILING, SHORING, BRACING ETC. AGAINST SUCH BANK OR SIDES.** Adequate and suitable warning signs shall be put up at conspicuous places at the excavation work to prevent any persons or vehicles falling into the excavation trench. No worker should be allowed to work where he may be stuck or endangered by excavation machinery or collapse of excavations or trenches.
1.05.00	**EXCAVATION IN ROCK** Excavation in rock shall be carried out by mechanical means and if blasting is required for founding of some of the structures under this package, control blasting only shall be carried out.
1.05.01	Controlled blasting shall be done by a specialised agency duly approved by Engineer. All controlled blasting shall be done by using time delay detonators (i.e. excel type).
1.05.02	a) Contractor shall engage an agency expert in blasting such as, NIRM (National Institute of Rock Mechanics), CMPDIL, Central Institute of Mining and Fuel Research Dhanbad, Dept. of Mining of Govt. Institutions etc. to design detailed blasting scheme and get the same approved from Engineer before carrying out the blasting operation. All blasting shall be done as per the approved blasting scheme & initial blasting operations shall be done under the supervision & guidance of the representative of the blasting expert. b) All the statutory laws, (Explosives Act etc.) rules, regulations, Indian Standards, etc. pertaining to the acquisition, transport, storage, handling and use of explosives, etc. shall be strictly followed. c) The Contractor shall obtain Licenses from Competent Authorities for undertaking blasting work as well as for procuring, transporting to site and storing the explosives as per explosives act. The Contractor shall be responsible for the safe transport, use, custody and proper accounting of the explosive Materials. d) The Contractor shall be responsible and liable for any accident and injury / damage which may occur to any person or property of the project or public on account of any operations connected with the storage, transportation, handling or use of explosive and blasting operations.
1.06.00	**Sheeting & Shoring** The contractor shall ascertain for himself the nature of materials to be excavated and difficulties, if any, likely to be encountered in excavation while executing the work. Sheet piling, sheeting and shoring, bracing and maintaining suitable slopes,

drainage, etc. shall be provided and installed by the Contractor, to the satisfaction of the Engineer.

1.07.00 Geotechnical Investigation

The Contractor shall carry out detailed geotechnical investigation in the areas under his scope for establishing the sub-surface conditions and to decide type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for remedial measures for sub-soil/ foundations etc. in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils etc. prior to commencement of detailed design/drawings. The Contractor shall obtain the approval for the field testing scheme proposed by him from the Owner before undertaking the geotechnical investigation work.

1.07.01.00 **Scheme of geotechnical Investigation**

1.07.02.01 Field test shall include but not be limited to the following:

Boreholes, Standard Penetration Test (SPT), Dynamic Cone Penetration Test (DCPT), collection of disturbed samples (DS) and undisturbed soil samples (UDS), Trial Pits (TP), Plate Load Tests (PLT), Electrical Resistivity Test (ERT), In situ field permeability tests, collection of water samples, etc.

1.07.02.02 The diameter of borehole shall be minimum 150 mm in soil and 76 mm in rock. The diameter of UDS sampler shall be 100 mm minimum. Core drilling in rock shall be done by using hydraulically feed rotary drill & double tube core barrel with diamond bit.

1.07.02.03 The minimum tests are indicated in Clause No. 7.08.00. Adequate number of tests shall be conducted up to sufficient depth for complete determination of subsoil conditions. The depth of boreholes shall be as specified in Appendix A. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20%, met within a borehole. This test shall be conducted at every 3.0 m interval or at change of strata, up to the final depth. SPT 'N' of 100 and above shall be referred as refusal. UDS shall be collected at every 3.0 m interval or at change of strata up to depth of borehole. UDS may be replaced by additional SPT, if SPT'N' value in the strata is above 50.

1.07.02.04 Laboratory tests shall be done as per relevant IS codes. The laboratory tests, not be limited to the following shall be conducted on disturbed and undisturbed soil samples, rock samples & water samples collected during field investigations in sufficient numbers.

Laboratory Tests on Soil Samples

Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel.

Laboratory Tests on Rock Samples

Moisture content, porosity & density, Specific Gravity, Hardness, Soundness, Slake durability index, Unconfined compression test (Both at saturated and in-situ water content), Point load strength index and deformability test (Both at saturated and in-situ water content) shall be carried out on rock samples.

1.07.02.05 Geotechnical investigation (field & laboratory) shall be carried out in accordance with the provisions of relevant Indian Standards.

On completion of all field & laboratory work, geotechnical investigation report shall be submitted for Owner's review/approval. The Geotechnical investigation report shall contain geological information of the region, procedure adopted for investigation, field & laboratory observations/ data/ records, analysis of results & recommendations on type of foundation for different type of structures envisaged for all areas of work with supporting calculations. Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc.

Recommendations on foundation system and the net allowable bearing pressures and pile capacity shall be based on the conservative values of geotechnical investigation data.

1.07.03.00 Geotechnical investigation work shall be got executed by the Contractor through the following agencies.

1. C.E.TESTING COMPANY Pvt. Ltd, Kolkata
2. Cengrs Geotechnica Pvt. Ltd, New Delhi
3. M.K. Soil Testing Laboratory, Ahemdabad
4. SECON Pvt Ltd, Bangalore
5. Soil Engineering Consultants, New Delhi
6. Orbital Infrastructure Consultancy & Research Pvt. Ltd. Cuttack
7. KCT Consultancy Services, Ahemdabad
8. ARKITECHNO Consultants (India) Pvt. Ltd. Bhubaneswar

1.08.00 Geotechnical Investigation Scheme

a) **Boreholes (Minimum)**

S.N	Structure	Spacing/Number of borehole	Depth of borehole	Remarks
1	FGD	Minimum 14 Nos.	Depth of boreholes shall be 20m to 25m.	Depth of boreholes shall be as mentioned in column "Depth of Borehole" or 5m continuous
2	Crusher House	Minimum 2 Nos.	Depth of boreholes shall be 20m to 25m.	
3	Gypsum and Lime storage area	Minimum 10 Nos.	Depth of boreholes shall be 10m to 15m	

4	Chimney	Minimum 2 Nos.	25 to 30 m	in rock with RQD > 50% whichever is earlier.
5	Other Structure/Facility	Minimum 2 Nos. boreholes under each area / facility	15 to 20 m	
b) Other Field Tests (Minimum)				
1	Cyclic Plate Load Test (CPLT)	3 nos	Test Depth from 2 to 4 m	
2	**TRIAL PIT (TP)**	5 Nos.	Depth - 3 m	
3	**IN SITU PERMEABILITY TEST IN BOREHOLES**	In minimum 3 Nos. of boreholes	Tests shall be conducted at depths of 1.0m, 3.0m, 5.0m, 8.0m and 12.0m.	
4	**ERT**	Minimum 10 Nos.		

- Depth and location of Boreholes and other field tests (PLT, ERT, field permeability tests etc.) shall be approved by Owner before execution of geotechnical investigation work.
- Investigation in any other building / structure / facilities / trestles which are not mentioned above shall also be carried out, if required, by the bidder for the facilities under his scope.

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 23/12/2014** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.1 — Co-ordinates E=7937 N=12065

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	6	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	6
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 11/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 459.320 m.
Water Struck At :
Standing Water Level : 1.65 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m				
Stiff, yellowish brown to brownish grey, silty clay / clayey silt with decomposed rock. Obs. kankar & sand mixture.		3 4 6 (10) 4 4 8 (12) 5 6 9 (15) 22 47 31 (>100) 4.0 cm Pentn. Refusal	DS-1 SPT-1 UDS-1 SPT-2 UDS-2 SPT-3 SPT-4 *SPT-5 *SPT-6	0.50 1.00-1.45 2.00-2.45 2.45-2.90 3.50-3.95 3.95-4.40 5.00-5.34 5.55-5.60 5.75-5.78
5.75m		100 5.0 cm Pentn. Refusal 100 3.0 cm Pentn.		5.75
Highly weathered, light greyish brown, fine grained, highly fractured shale.		NX rotary drilling from 5.75m to 32.50m	R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14	CR=21% RQD=Nil CR=29% RQD=Nil CR=24% RQD=Nil CR=33% RQD=Nil CR=36% RQD=Nil CR=44% RQD=32% CR=53% RQD=37% CR=52% RQD=41% CR=45% RQD=31% CR=51% RQD=47% CR=57% RQD=31% CR=53% RQD=Nil CR=57% RQD=32% CR=52% RQD=13%
8.00m				6.50
Highly weathered, light greyish brown, fine grained, highly fractured shale.				7.25
8.75m				8.00
Highly to moderately weathered, brownish grey, fine grained, moderately fractured sandstone.				8.75
10.25m				9.50
Moderately weathered, brownish grey, fine grained, moderately fractured sandstone.				10.25
11.00m				11.00
Moderately weathered, light greyish brown, medium to fine grained, moderately fractured sandstone.				11.75 12.50 13.25 14.00 14.75 15.50
15.50m				
16.30m				16.25

BH-1/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | Created by : SKD | Created on : 23/12/2014 | Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.1

Co-ordinates E=7937 N=12065

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	6	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	6
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 11/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 459.32 m.
Water Struck At :
Standing Water Level : 1.65 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
16.30m				
			R15	CR=55% RQD=43% 17.00
			R16	CR=67% RQD=49% 17.75
			R17	CR=69% RQD=55% 18.50
			R18	CR=74% RQD=53% 19.25
			R19	CR=68% RQD=44% 20.00
			R20	CR=81% RQD=74% 20.75
			R21	CR=83% RQD=64% 21.50
			R22	CR=81% RQD=40% 23.00
Moderately to slightly weathered / fresh, light blackish grey, fine grained, moderately to slightly fractured sandstone.			R23	CR=84% RQD=47% 24.50
			R24	CR=82% RQD=58% 26.00
			R25	CR=85% RQD=42% 27.50
			R26	CR=83% RQD=69% 29.00
			R27	CR=86% RQD=65% 30.50
			R28	CR=85% RQD=68% 32.00
N.B. – '*' means sample could not be recovered. 32.50m			R29	CR=88% RQD=84% 32.50

BH-1/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 23/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.2

Co-ordinates E=7925 N=12047

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	4	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	4
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	1

Commencement Date : 08/12/2014
Completion Date : 11/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 459.70 m.
Water Struck At :
Standing Water Level : 1.65 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m Stiff, yellowish brown, silty clay / clayey silt. Obs. kankar & sand mixture.		3 5 6 — 11	DS-1 SPT-1 WS-1	0.50 1.00-1.45 1.65
1.90m Hard, brownish grey, silty clay / clayey silt with mica & decomposed rock.		17 38 45 — ≥100 (10.0 cm Pentn.) 100 — Refusal (4.0 cm Penetn.) 100 — Refusal (3.0 cm Penetn.)	*UDS-1 SPT-2 *SPT-3 *SPT-4	2.00-2.10 2.10-2.50 2.70-2.74 2.90-2.93
2.90m NX rotary drilling from 2.90m to 30.00m Highly to moderately weathered, brownish grey, medium to fine grained, moderately fractured, alternation of sandstone & shale.			R1 R2 R3 R4 R5 R6 R7 R8 R9	CR=28% RQD=Nil (2.90-3.50) CR=36% RQD=32% (3.50-4.25) CR=35% RQD=Nil (4.25-5.00) CR=39% RQD=Nil (5.00-5.75) CR=40% RQD=20% (5.75-6.50) CR=41% RQD=Nil (6.50-7.25) CR=43% RQD=23% (7.25-8.00) CR=45% RQD=Nil (8.00-8.75) CR=47% RQD=20% (8.75-9.50)
9.50m Moderately to slightly weathered, brownish grey, medium to fine grained, moderately fractured alternation of sandstone & shale.			R10 R11 R12 R13 R14 R15 R16 R17 R18	CR=51% RQD=27% (9.50-10.25) CR=44% RQD=28% (10.25-11.00) CR=51% RQD=20% (11.00-11.75) CR=55% RQD=13% (11.75-12.50) CR=57% RQD=Nil (12.50-13.25) CR=52% RQD=13% (13.25-14.00) CR=64% RQD=49% (14.00-14.75) CR=69% RQD=55% (14.75-15.50) CR=61% RQD=31% (15.50-16.25)
16.30m				

BH-2/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 23/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.9

Co-ordinates E=7939 N=11986

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	4	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	4
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 11/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.398 m.
Water Struck At :
Standing Water Level : 2.30 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m				
Hard, brownish grey, silty clay / clayey silt with mica & decomposed rock.		12 20 24 — 44	DS-1	0.50
			SPT-1	1.00-1.45
		22 43 35 — >100	*UDS-1	2.10-2.20
		4.0 cm Pentn.	SPT-2	2.20-2.54
		100 — Refusal		
		5.0 cm Pentn.	*SPT-3	3.00-3.05
3.25m		100 — Refusal	*SPT-4	3.25-3.29 3.25
		4.0 cm Pentn.	R1	CR=29% RQD=Nil 4.00
		NX rotary drilling from 3.25m to 25.00m	R2	CR=39% RQD=Nil 4.75
			R3	CR=32% RQD=19% 5.50
Highly to moderately weathered, brownish grey, fine grained, highly to moderately fractured, alternation of sandstone & shale.			R4	CR=35% RQD=28% 6.25
			R5	CR=44% RQD=31% 7.00
			R6	CR=49% RQD=39% 7.75
			R7	CR=47% RQD=20% 8.50
			R8	CR=48% RQD=Nil 9.25
			R9	CR=50% RQD=Nil 10.00
10.00m			R10	CR=53% RQD=37% 10.75
Moderately to slightly weathered, brownish grey, fine grained, highly to moderately fractured, alternation of sandstone & shale.			R11	CR=63% RQD=55% 11.50
			R12	CR=61% RQD=43% 12.25
12.25m			R13	CR=64% RQD=59% 13.00
Moderately to slightly weathered, light brownish grey, fine grained, moderately fractured alternation of sandstone & shale.			R14	CR=56% RQD=32% 13.75
13.75m			R15	CR=60% RQD=13% 14.50
Moderately to slightly weathered / fresh, brownish grey to light blackish grey, fine grained, medium to slightly fractured, alternation of sandstone & shale.			R16	CR=63% RQD=Nil 15.25
			R17	CR=61% RQD=Nil 16.00
16.30m				

BH-9/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 23/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.9

Co-ordinates E=7939 N=11986

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	4	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	4
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 11/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.398 m.
Water Struck At :
Standing Water Level : 2.30 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
16.30m.				
Moderately to slightly weathered / fresh, brownish grey to light blackish grey, fine grained, medium to slightly fractured, alternation of sandstone & shale.			R18	CR=64% RQD=13% 16.75
			R19	CR=66% RQD=55% 17.50
			R20	CR=64% RQD=33% 18.25
			R21	CR=69% RQD=35% 19.00
			R22	CR=73% RQD=16% 19.75
			R23	CR=81% RQD=44% 20.50
			R24	CR=84% RQD=80% 21.25
			R25	CR=83% RQD=72% 22.75
			R26	CR=85% RQD=69% 24.25
			R27	CR=88% RQD=75% 25.00
25.00m.				

N.B. – '*' means sample could not be recovered.

BH-9/Sheet-2

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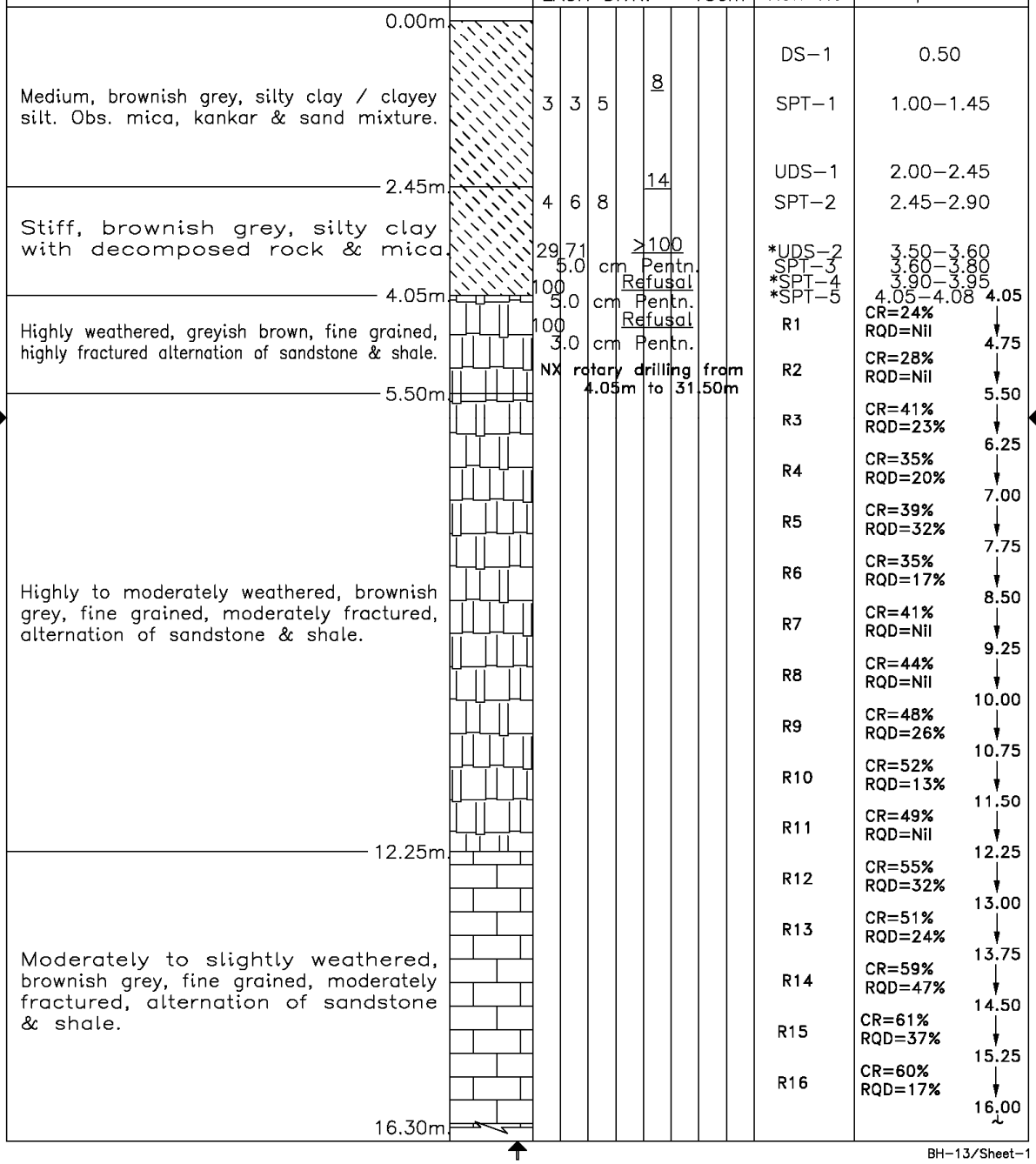
Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 23/12/2014** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.13 — Co-ordinates E=7937 N=11932

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 05/12/2014
Completion Date : 10/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.287 m.
Water Struck At :
Standing Water Level : 3.10 m.



BH-13/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | Created by : SKD | Created on : 23/12/2014 | Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.13

Co-ordinates E=7937 N=11932

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 05/12/2014
Completion Date : 10/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.287 m.
Water Struck At :
Standing Water Level : 3.10 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
16.30m. Moderately to slightly weathered, brownish grey, fine grained, moderately fractured, alternation of sandstone & shale.			R17 CR=55% RQD=24%	16.75
			R18 CR=61% RQD=37%	17.50
			R19 CR=72% RQD=56%	18.25
18.25m. Slightly weathered, light greyish brown, fine grained, moderately fractured alternation of sandstone & shale.			R20 CR=67% RQD=45%	19.00
			R21 CR=64% RQD=25%	19.75
20.50m.			R22 CR=62% RQD=23%	20.50
			R23 CR=67% RQD=53%	21.25
			R24 CR=64% RQD=33%	22.00
			R25 CR=70% RQD=48%	22.75
			R26 CR=71% RQD=65%	23.50
Slightly weathered, light blackish grey, fine grained, moderately to slightly fractured, alternation of sandstone & shale.			R27 CR=73% RQD=72%	24.25
			R28 CR=70% RQD=36%	25.00
			R29 CR=73% RQD=27%	25.75
			R30 CR=75% RQD=15%	26.50
			R31 CR=73% RQD=69%	27.25
			R32 CR=76% RQD=71%	28.00
28.00m.			R33 CR=81% RQD=78%	28.75
			R34 CR=84% RQD=73%	29.50
Fresh, light blackish grey, fine grained, moderately fractured alternation of sandstone & shale.			R35 CR=86% RQD=58%	
			R36 CR=92% RQD=52%	31.00
31.50m.				31.50
N.B. – '*' means sample could not be recovered.				

BH-13/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 23/12/2014** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.15 — Co-ordinates E=7925 N=11914

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 10/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.141 m.
Water Struck At :
Standing Water Level : 3.10 m.

DESCRIPTION	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	Depth (m)
0.00m Stiff, yellowish brown to brownish grey, silty clay / clayey silt with mica & decomposed rock.	2 5 6 — 11	DS-1	0.50
		SPT-1	1.00-1.45
2.09m Hard, brownish grey, silty clay / / clayey silt with mica & decomposed rock.	13 22 31 — 53	*UDS-1	2.00-2.09
		SPT-2	2.09-2.54
	34 66 — >100 (9.0 cm Pentn.)	SPT-3	2.90-3.14
	100 — Refusal (4.0 cm Penth.)	SPT-4	3.30-3.34
3.50m	100 — Refusal (3.0 cm Penth.)	SPT-5	3.50-3.53
	NX rotary drilling from 3.50m to 30.00m		
Highly to moderately weathered, brownish grey, fine to medium grained, highly to moderately fractured, alternation of sandstone & shale.		R1	CR=26% RQD=Nil (3.50 - 4.25)
		R2	CR=29% RQD=13% (4.25 - 5.00)
		R3	CR=28% RQD=15% (5.00 - 5.75)
		R4	CR=36% RQD=Nil (5.75 - 6.50)
		R5	CR=35% RQD=Nil (6.50 - 7.25)
		R6	CR=47% RQD=17% (7.25 - 8.00)
		R7	CR=37% RQD=Nil (8.00 - 8.75)
		R8	CR=41% RQD=13% (8.75 - 9.50)
		R9	CR=45% RQD=35% (9.50 - 10.25)
10.25m Moderately weathered, brownish grey, fine grained, moderately fractured, alternation of sandstone & shale.		R10	CR=41% RQD=Nil (10.25 - 11.00)
11.00m		R11	CR=52% RQD=Nil (11.00 - 11.75)
Moderately to slightly weathered, brownish grey, fine grained, moderately fractured, alternation of siltstone & shale.		R12	CR=52% RQD=47% (11.75 - 12.50)
		R13	CR=65% RQD=42% (12.50 - 13.25)
		R14	CR=52% RQD=47% (13.25 - 14.00)
14.00m Moderately to slightly weathered / fresh, brownish grey to light blackish grey, fine grained, moderately fractured, alternation of sandstone & shale.		R15	CR=56% RQD=32% (14.00 - 14.75)
		R16	CR=57% RQD=Nil (14.75 - 15.50)
		R17	CR=60% RQD=Nil (15.50 - 16.25)
16.30m			

BH-15/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | Created by : SKD | Created on : 23/12/2014 | Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.15 — Co-ordinates E=7925 N=11914

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 10/12/2014
Completion Date : 13/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.141 m.
Water Struck At :
Standing Water Level : 3.10 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
16.30m.				
			R18	CR=61% RQD=35% 17.00
			R19	CR=64% RQD=44% 17.75
			R20	CR=63% RQD=Nil 18.50
			R21	CR=60% RQD=33% 19.25
			R22	CR=67% RQD=40% 20.00
			R23	CR=64% RQD=24% 20.75
			R24	CR=68% RQD=56% 21.50
			R25	CR=73% RQD=65% 22.25
Moderately to slightly weathered / fresh, brownish grey to light blackish grey, fine grained, moderately fractured, alternation of sandstone & shale.			R26	CR=70% RQD=32% 23.00
			R27	CR=80% RQD=24% 23.75
			R28	CR=83% RQD=Nil 24.50
			R29	CR=85% RQD=36% 26.00
			R30	CR=82% RQD=15% 27.50
			R31	CR=84% RQD=13% 28.50
			R32	CR=87% RQD=56% 30.00
30.00m.				

N.B. – '*' means sample could not be recovered.

BH-15/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 23/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.18 — Co-ordinates E=7939 N=11853

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	6	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	6
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 14/12/2014
Completion Date : 15/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 458.447 m.
Water Struck At :
Standing Water Level : 3.40 m.

DESCRIPTION	SYMBOL	N–VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m				
Stiff, yellowish brown, silty clay / clayey silt. Observed kankar.		4 6 8 (14)	DS–1	0.50
			SPT–1	1.00–1.45
		4 5 9 (14)	UDS–1	2.00–2.45
			SPT–2	2.45–2.90
2.90m				
Hard, brownish grey, silty clay / clayey silt with decomposed rock & mica.		7 15 28 (43)	SPT–3	3.30–3.75
		31 69 / 5.0 cm (≥100) Pentn.	SPT–4	4.00–4.20
		100 / 5.0 cm Refusal Pentn.	*SPT–5	4.30–4.35
4.45m			*SPT–6	4.45–4.48
Highly weathered, brownish grey, medium grained, highly fractured, alternation of sandstone & shale. 5.00m		100 / 3.0 cm Refusal Pentn.	R1	CR=23% RQD=Nil
		NX rotary drilling from 4.45m to 25.00m	R2	CR=28% RQD=Nil
			R3	CR=29% RQD=16%
			R4	CR=24% RQD=Nil
			R5	CR=30% RQD=16%
			R6	CR=34% RQD=22%
			R7	CR=38% RQD=16%
Highly to moderately weathered, brownish grey to light blackish grey, medium to fine grained, highly to moderately fractured, alternation of sandstone & shale.			R8	CR=40% RQD=Nil
			R9	CR=45% RQD=Nil
			R10	CR=48% RQD=20%
			R11	CR=44% RQD=32%
			R12	CR=52% RQD=16%
			R13	CR=48% RQD=Nil
14.00m			R14	CR=58% RQD=49%
Moderately weathered, brownish grey to light blackish grey, medium to fine grained, highly to moderately fractured, alternation of sandstone & shale.			R15	CR=52% RQD=32%
15.50m			R16	CR=50% RQD=45%
16.30m				

4.45 5.00 5.75 6.50 7.25 8.00 8.75 9.50 10.25 11.00 11.75 12.50 13.25 14.00 14.75 15.50 16.25

BH–18/Sheet–1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | Created by : SKD | Created on : 23/12/2014 | Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.18

Co-ordinates E=7939 N=11853

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	6	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	6
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 14/12/2014
Completion Date : 15/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 458.447 m.
Water Struck At :
Standing Water Level : 3.40 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
16.30m. Moderately weathered, brownish grey to light blackish grey, medium to fine grained, highly to moderately fractured, alternation of sandstone & shale. 17.75m.			R17	CR=52% RQD=Nil 17.00
			R18	CR=50% RQD=Nil 17.75
			R19	CR=52% RQD=17% 18.50
			R20	CR=50% RQD=32% 19.25
			R21	CR=52% RQD=13% 20.00
			R22	CR=57% RQD=Nil 20.75
Moderately to slightly weathered, light blackish grey, fine grained, moderately fractured, alternation of sandstone & shale.			R23	CR=56% RQD=13% 21.50
			R24	CR=62% RQD=25% 22.25
			R25	CR=65% RQD=25% 23.00
			R26	CR=67% RQD=21% 23.75
			R27	CR=66% RQD=24% 24.50
			R28	CR=68% RQD=29% 25.00
25.00m.				

N.B. – '*' means sample could not be recovered.

BH-18/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 17/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.22

Co-ordinates E=7937 N=11798

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 01/12/2014
Completion Date : 05/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 457.457 m.
Water Struck At :
Standing Water Level : 2.3 m.

DESCRIPTION	N-VALUE (EACH DIVN. = 15cm)	Ref. No	Depth (m)
0.00m Stiff, yellowish brown, silty clay / clayey silt. Observed kankar & sand mixture.	3 4 5 (9) 3 5 6 (11)	DS-1 SPT-1 UDS-1 SPT-2	0.50 1.00-1.45 2.00-2.45 2.45-2.90
3.70m Hard, brownish grey, silty clay / clayey silt with decomposed rock.	24 76 (>100) 11.0 cm Pentn. Refusal 100 5.0 cm Pentn. Refusal	*UDS-2 SPT-3 *SPT-4	3.60-3.70 3.70-3.96 4.60-4.65
5.00m Highly weathered, brownish grey, fine grained, highly fractured sand stone.	100 3.0 cm Pentn. NX rotary drilling from 5.00m to 29.50m	*SPT-5 R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13	5.00-5.03 CR=40% RQD=Nil CR=32% RQD=Nil CR=27% RQD=Nil CR=23% RQD=Nil CR=25% RQD=Nil CR=20% RQD=Nil CR=34% RQD=Nil CR=33% RQD=Nil CR=35% RQD=Nil CR=40% RQD=Nil CR=49% RQD=32% CR=51% RQD=28% CR=59% RQD=49%
7.25m Completely to highly weathered, brownish grey, fine grained sand stone.			5.75 6.50 7.25 8.00 8.75
9.50m Highly weathered, brownish grey, fine grained sand stone.			9.50
10.25m Highly weathered, light grey, fine grained, highly fractured sand stone.			10.25 11.00 11.75
12.50m Moderately weathered, light blackish grey, fine grained, moderately fractured alternation of sandstone & shale. 13.25m			12.50 13.25
Moderately to slightly weathered to fresh, light blackish grey, fine grained, medium to slightly fractured alternation of sandstone & shale. 15.10m			14.00 14.75

BH-22/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401	Created by : SKD	Created on : 17/12/2014	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.22

Co-ordinates E=7937 N=11798

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 01/12/2014
Completion Date : 05/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 457.457 m.
Water Struck At :
Standing Water Level : 2.3 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
15.10m				
			R14	CR=57% RQD=44% 15.50
			R15	CR=59% RQD=47% 16.25
			R16	CR=61% RQD=16% 17.00
			R17	CR=63% RQD=19% 17.75
			R18	CR=67% RQD=31% 18.50
			R19	CR=65% RQD=51% 19.25
			R20	CR=60% RQD=16% 20.00
			R21	CR=69% RQD=48% 20.75
			R22	CR=73% RQD=35% 21.50
			R23	CR=68% RQD=17% 22.25
			R24	CR=74% RQD=23% 23.00
			R25	CR=75% RQD=32% 23.75
			R26	CR=72% RQD=40% 24.50
			R27	CR=76% RQD=52% 25.25
			R28	CR=69% RQD=57% 26.00
			R29	CR=64% RQD=54% 26.75
			R30	CR=73% RQD=50% 27.50
			R31	CR=85% RQD=58% 28.25
			R32	CR=88% RQD=56% 29.00
			R33	CR=87% RQD=62% 29.50
Moderately to slightly weathered / fresh, light blackish grey, fine grained, medium to slightly fractured alternation of sandstone & shale.				
29.50m				
N.B. – '*' means sample could not be recovered.				

BH-22/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 23/12/2014** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.24 — Co-ordinates E=7925 N=11783

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	7	Undisturbed (UDS)	3
Cone (Pc)		Penetrometer (SPT)	7
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 06/12/2014
Completion Date : 10/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 457.219 m.
Water Struck At :
Standing Water Level : 2.40 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m				
		2 3 5 (8)	DS-1	0.50
			SPT-1	1.00-1.45
Stiff, brownish grey, silty clay / clayey silt. Observed kankar & sand mixture.		3 5 5 (10)	UDS-1	2.00-2.45
			SPT-2	2.45-2.90
		3 5 6 (11)	UDS-2	3.50-3.95
			SPT-3	3.95-4.40
5.10m				
		11 19 22 (41)	*UDS-3	5.20-5.32
			SPT-4	5.32-5.77
Hard, brownish grey, silty clay / clayey silt with mica & decomposed rock.		17 36 47 >100 10.0 cm Pentn.	SPT-5	6.20-6.60
		100 Refusal 5.0 cm Pentn.	*SPT-6	6.80-6.85
7.00m			*SPT-7	7.00-7.03
Highly weathered, brownish grey, fine grained, highly fractured sandstone.		100 Refusal 3.0 cm Pentn.	R1	CR=23% RQD=Nil 7.00-7.75
7.75m		NX rotary drilling from 7.00m to 30.00m	R2	CR=27% RQD=13% 7.75-8.50
			R3	CR=28% RQD=Nil 8.50-9.25
			R4	CR=29% RQD=Nil 9.25-10.00
			R5	CR=25% RQD=Nil 10.00-10.75
Highly to moderately weathered, brownish grey, fine grained, highly fractured sandstone.			R6	CR=32% RQD=Nil 10.75-11.50
			R7	CR=35% RQD=Nil 11.50-12.25
			R8	CR=36% RQD=13% 12.25-13.00
			R9	CR=49% RQD=Nil 13.00-13.75
			R10	CR=40% RQD=Nil 13.75-14.50
14.50m			R11	CR=49% RQD=Nil 14.50-15.25
Highly to moderately weathered, brownish grey, fine grained, highly fractured, alternation of sandstone & shale. 15.25m			R12	CR=56% RQD=29% 15.25-16.00
16.30m				

BH-24/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | Created by : SKD | Created on : 23/12/2014 | Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.24 — Co-ordinates E=7925 N=11783

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	7	Undisturbed (UDS)	3
Cone (Pc)		Penetrometer (SPT)	7
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 06/12/2014
Completion Date : 10/12/2014
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 457.219 m.
Water Struck At :
Standing Water Level : 2.40 m.

DESCRIPTION	SYMBOL	N-VALUE (EACH DIVN. = 15cm)	Ref. No	SAMPLES Depth (m)
16.30m			R13	CR=63% RQD=43% 16.75
			R14	CR=67% RQD=51% 17.50
			R15	CR=69% RQD=65% 18.25
			R16	CR=65% RQD=16% 19.00
			R17	CR=71% RQD=48% 19.75
			R18	CR=65% RQD=16% 20.50
			R19	CR=69% RQD=Nil 21.25
			R20	CR=72% RQD=Nil 22.00
Moderately to slightly weathered to fresh, light blackish grey, fine grained, moderately fractured, alternation of sandstone & shale.			R21	CR=76% RQD=Nil 22.75
			R22	CR=80% RQD=45% 23.50
			R23	CR=76% RQD=50% 24.25
			R24	CR=78% RQD=46% 25.00
			R25	CR=77% RQD=29% 25.75
			R26	CR=80% RQD=37% 26.50
			R27	CR=81% RQD=20% 27.25
			R28	CR=79% RQD=22% 28.00
			R29	CR=82% RQD=34% 28.75
			R30	CR=81% RQD=40%
30.00m				30.00

N.B. – '*' means sample could not be recovered.

BH-24/Sheet-2

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 31/01/2015** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.105 — Co-ordinates E=7774 N=11928

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	2
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 10/01/2015
Completion Date : 11/01/2015
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 461.519 m.
Water Struck At :
Standing Water Level : 3.0 m.

DESCRIPTION	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m Very stiff, yellowish brown, silty clay. Observed kankar & sand mixture.	4 6 11 (17)	DS-1	0.50
		SPT-1	1.00-1.45
	5 8 13 (21)	UDS-1	2.00-2.45
		SPT-2	2.45-2.90
3.20m Hard, brownish grey, silty clay / clayey silt. Obs. decomposed rock.	25 52 23 (≥100) 4.0 cm Pentn.	*UDS-2	3.50-3.60
		SPT-3	3.60-3.94
	100 Refusal 5.0 cm Pentn.	*SPT-4	4.20-4.25
4.50m Highly weathered, greyish brown, fine grained, highly fractured alternation of sandstone & shale. 5.25m		*SPT-5	4.50-4.53
	100 Refusal 3.0 cm Pentn.	R1	CR=25% RQD=Nil
	NX rotary drilling from 4.50m to 20.00m	R2	CR=26% RQD=Nil
		R3	CR=29% RQD=14%
		R4	CR=28% RQD=13%
		R5	CR=35% RQD=Nil
		R6	CR=32% RQD=Nil
		R7	CR=32% RQD=19%
Highly to moderately weathered, greyish brown, fine grained, highly fractured alternation of sandstone & shale.		R8	CR=31% RQD=14%
		R9	CR=30% RQD=Nil
		R10	CR=38% RQD=16%
		R11	CR=40% RQD=28%
		R12	CR=38% RQD=Nil
		R13	CR=40% RQD=Nil
		R14	CR=42% RQD=Nil
		R15	CR=44% RQD=Nil
15.75m Moderately weathered, brownish grey, fine grained, highly fractured alternation of sandstone & shale.		R16	CR=41% RQD=Nil
		R17	CR=42% RQD=20%
		R18	CR=44% RQD=Nil
		R19	CR=37% RQD=Nil
		R20	CR=42% RQD=Nil
N.B. – '*' means sample could not be recovered.		R21	CR=48% RQD=14%
20.00m			4.50 5.25 6.00 6.75 7.50 8.25 9.00 9.75 10.50 11.25 12.00 12.75 13.50 14.25 15.00 15.75 16.50 17.25 18.00 18.75 19.50 20.00

BH-105/Sheet-1

Project : G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No : 3401 | **Created by : SKD** | **Created on : 31/01/2015** | **Sheet No:**

BORE LOG DATA SHEET — BORE HOLE NO.109 — Co-ordinates E=7763 N=12110

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	5	Undisturbed (UDS)	1
Cone (Pc)		Penetrometer (SPT)	5
Vane (V)		Disturbed (DS)	1
		Water Sample (WS)	0

Commencement Date : 08/01/2015
Completion Date : 09/01/2015
Bore Hole Diameter : 150mm / NX.
Level Of Ground : 460.577 m.
Water Struck At :
Standing Water Level : 3.0 m.

DESCRIPTION	N-VALUE (EACH DIVN. = 15cm)	SAMPLES Ref. No	SAMPLES Depth (m)
0.00m Stiff, yellowish brown, silty clay. Observed kankar.	3 4 7 (11)	DS-1 SPT-1	0.50 1.00-1.45
1.90m Stiff, yellowish brown, silty clay / clayey silt with sand mixture & mica. Obs. decomposed rock.	3 6 8 (14)	UDS-1 SPT-2	2.00-2.45 2.45-2.90
	3 16 67/13.0 cm Pentn. (≥100)	SPT-3 *SPT-4	3.20-3.48 3.60-3.65
3.75m Highly weathered, brownish grey, fine grained, highly fractured sandstone.	100/5.0 cm Pentn. Refusal	*SPT-5	3.75-3.78
4.50m	100/3.0 cm Pentn. Refusal	R1	CR=25% RQD=Nil 3.75 – 4.50
	NX rotary drilling from 3.75m to 15.00m	R2	CR=28% RQD=Nil 4.50 – 5.25
Highly weathered, brownish grey to light blackish grey, fine grained, highly fractured alternation of sandstone & shale.		R3	CR=31% RQD=Nil 5.25 – 6.00
		R4	CR=27% RQD=Nil 6.00 – 6.75
		R5	CR=28% RQD=Nil 6.75 – 7.50
		R6	CR=27% RQD=Nil 7.50 – 8.25
		R7	CR=30% RQD=Nil 8.25 – 9.00
		R8	CR=33% RQD=Nil 9.00 – 9.75
		R9	CR=35% RQD=Nil 9.75 – 10.50
Highly weathered, brownish grey to light blackish grey, fine grained, highly fractured sandstone. 11.25m 12.00m		R10	CR=36% RQD=Nil 10.50 – 11.25
		R11	CR=38% RQD=Nil 11.25 – 12.00
Moderately weathered, greyish brown, fine grained, highly fractured sandstone.		R12	CR=41% RQD=Nil 12.00 – 12.75
		R13	CR=45% RQD=Nil 12.75 – 13.50
		R14	CR=47% RQD=18% 13.50 – 14.25
15.00m		R15	CR=48% RQD=14% 14.25 – 15.00

N.B. – '*' means sample could not be recovered.

BH-109/Sheet-1

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No.: 3401 | Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classi fication	Grain Size Gravel %	Sand %	Silt %	Clay %	Test Method
BH01	UDS01	2.00	Brownish grey, silty clay with traces of kankars.	2.00	1.63	2.67	23 T 24 C	0.630	TR:SH-UU 3.0 2.0 1.0	0.669 0.537 0.514	0.57	0				CI*		3	88	9	**See the Note
BH01	UDS02	3.50	Brownish grey, silty clay with traces of sand mixtures & kankars	2.16	1.87	2.69	16 S 16 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.024 1.395 1.465 0.966 0.902 0.978	1.30 0.95	0 0	42	20	12	CI		20	76	4	Do
BH01	SPT04	5.00	Yellowish grey, silty clay with traces of fine sand mixture.													CI*		6	94 (Silt+Clay)		Do
BH02	SPT01	1.00	Yellowish grey, silty clay.										42	22		CI					Do
BH02	SPT02	2.10	Brownish grey, silty clay / clayey silt with sand mixtures.													CI*		35	65 (Silt+Clay)		Do
BH03	UDS01	1.90	Brownish grey, silty clay / clayey silt with traces of rusty spots.	1.94	1.62	2.73	19 S 20 T 20 C	0.650	TR:SH-UU 3.0 2.0 1.0	1.840 1.725 1.508	1.16	8	40	25	25	CI		23	75	2	Do
BH04	SPT04	5.22	Brownish grey, silty clay / clayey silt with sand mixture.													CI*		28	72 (Silt+Clay)		Do
BH05	SPT02	2.13	Brownish grey, silty clay with decomposed rock.													CI*		26	74 (Silt+Clay)		Do
BH06	SPT02	2.12	Brownish grey, silty clay / clayey silt with decomposed rock.													CI*		29	71 (Silt+Clay)		Do
BH07	SPT02	2.13	Brownish grey, silty clay with decomposed rock.										38	15		CI					Do

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Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No.: 3401 | Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn. kg/sqcm	Frictn. Deg.	Atter. Limits LL %	PL %	SL %	IS Classi fication	Grain Size Gravel %	Sand %	Silt %	Clay %	Test Method
EH12	UDS01	2.00	Brownish grey, silty clay / clayey silt with traces of kankars.	1.94	1.55	2.63	26 S 26 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	0.17 0.179 0.155 0.163 0.11 0.112 0.101 0.104	0.17	0	39	20	19	CI		22	73	5	Do
EH14	SPT02	2.10	Brownish grey, silty clay with sandmixtures.													CI*		35	65 (Silt+Clay)		Do
EH15	SPT02	2.09	Brownish grey, silty clay with sandmixture & mica.													CI*		21	79 (Silt+Clay)		Do
EH16	UDS01	2.00	Brownish grey, silty clay / clayey silt with traces of sandmixture.	1.96	1.68	2.70	16 S 16 T 17 C	0.495	TRSH-UU 3.0 2.0 1.0	0.498 0.428 0.380	0.44	0	30	17	17	CL		37	62	1	Do
EH17	UDS01	2.00	Yellowish brown, silty clay / clayey silt with traces of kankars.	1.97	1.58	2.64	26 S 25 T		TRSH-UU 3.0 2.0 1.0	1.694 1.528 1.346	1.52	0				CI*		33	64	3	Do
EH18	UDS01	2.00	Yellowish brown, silty clay / clayey silt with traces of kankars.	1.68	1.41	2.69	19 S 19 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	0.342 0.433 0.440 0.244 0.313 0.301	0.41 0.29	0 0	43	19	14	CI		21	77	2	Do
EH19	UDS01	2.00	Brownish grey, silty clay with traces of kankars.	2.12	1.85	2.65	13 S 15 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.416 2.100 1.653 1.406 1.302 1.186	1.72 1.30	0 0	38	18		CI		8	81	11	Do

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Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No. : 3401 | **Sheet No.**

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %	Test Method
BH19	SPT06	6.00	Brownish grey, silty clay / clayey silt with sand mixtures.													CI*		38	62 (Silt+Clay)		Do
BH20	UDS01	2.00	Yellowish grey, silty clay / clayey silt with traces of sand mixtures.	2.01	1.71	2.70	18 S 18 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.217 0.858 0.884 0.649 0.646 0.641	0.99 0.64	0 0	35	19	18	CI		23	71	6	Do
BH21	UDS01	2.00	Yellowish grey, silty clay / clayey silt with traces of sand mixtures.	2.11	1.75	2.50	21 S 21 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	0.527 0.531 0.475 0.362 0.357 0.328	0.51 0.35	0 0	38	17	12	CI		30	66	4	Do
BH22	UDS01	2.00	Brownish grey, silty clay with traces of sand mixture.	2.06	1.78	2.64	16 S 16 T 17 C	0.534	TR:SH-UU 3.0 2.0 1.0 UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.617 1.594 1.104 1.013 1.058 0.905 0.694 0.674 0.612	0.71 0.99 0.66	12 0 0	30	16	17	CL		37	60	3	Do
BH22	SPT03	3.70	Brownish grey, clayey silt with sand mixture & mica.													CI*		36	64 (Silt+Clay)		Do
BH23	UDS01	2.00	Brownish grey clayey silt/ silty clay with traces of kankars.	2.11	1.84	2.72	14 S 15 T 18 C	0.542	TR:SH-UU 3.0 2.0 1.0	1.911 1.831 1.774	1.84	0	40	16	14	CI		15	80	5	Do

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No.: 3401 | **Sheet No.**

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	After Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %	Test Method
BH23	UDS02	3.50	Brownish grey clayey silt/ silty clay with traces of kankars.	2.16	1.89	2.70	15 S		UNCONFD		1.55	0	50	20	18	CH		12	86	2	Do
									0.0	1.767											
									0.0	1.306											
									0.0	1.577											
									REMOULD		1.09	0									
									0.0	1.207											
									0.0	1.075											
									0.0	0.998											
BH23	SPT05	5.60	Brownish grey, clayey silt with sand mixtures & traces of mica.													CI*		42	58 (Silt+Clay)		Do
BH24	UDS01	2.00	Yellowish grey, silty clay / clayey silt with traces of sand mixtures.	2.15	1.85	2.66	16 S	0.384	TRSH-UU		2.35	7	38	17	13	CI		20	70	10	Do
							16 T		3.0	3.126											
							15 C		2.0	2.913											
									1.0	2.833											
BH24	UDS02	3.50	Brownish grey, silty clay / clayey silt.				19 S		UNCONFD		0.52	0	38	16	12	CI					Do
									0.0	0.499											
									0.0	0.555											
									0.0	0.498											
									REMOULD		0.35	0									
									0.0	0.337											
									0.0	0.385											
									0.0	0.317											
BH24	SPT04	5.32	Brownish grey, silty clay / clayey silt with sand mixtures.													CI*		34	66 (Silt+Clay)		Do
BH25	UDS01	2.00	Brownish grey, silty clay with traces of kankars.	2.01	1.67	2.67	20 S	0.550	TRSH-UU		0.62	9	47	21	11	CI		6	80	14	Do
							20 T		3.0	1.345											
							22 C		2.0	1.054											
									1.0	0.988											
BH25	SPT03	3.62	Brownish grey, silty clay / clayey silt with sand mixtures and mica.			2.69										CI*		32	62	6	Do
BH26	UDS01	2.00	Brownish grey, silty clay with traces of rusty spots & kankars.	2.06	1.66	2.66	23 S		UNCONFD		0.65	0	48	21	16	CI		17	70	13	Do
							24 T		0.0	0.626											
									0.0	0.693											
									0.0	0.633											
									REMOULD		0.48	0									
									0.0	0.451											
									0.0	0.510											
									0.0	0.471											

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No.: 3401 | **Sheet No.**

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results: Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits: LL %	PL %	SL %	IS Classification	Grain Size: Gravl %	Sand %	Silt %	Clay %	Test Method
EH103	UDS01	2.00	Yellowish brown, silty clay with decomposed rock and mica.	2.03	1.74	2.68	17 S 17 T		UNCONFD 0.0 0.0 0.0	0.86 0.883 0.874 0.853	0.86	0				CI*		37	57	6	Do
									REMOULD 0.0 0.0 0.0	0.603 0.566 0.557	0.58	0									
EH105	SPT03	3.60	Light grey, silty clay with fine sand mixture & mica.										37	24		CI					Do
EH106	SPT01	1.00	Yellowish grey, silty clay.										44	23		CI					Do
EH106	SPT02	2.30	Light grey, silty clay / clayey silt with fine sand mixture & mica.													CI*		21	79	(Silt+Clay)	Do
EH107	UDS01	2.00	Yellowish brown, silty clay / clayey silt with traces of kankars.	2.04	1.64	2.67	24 S 24 T						43	19	13	CI		13	80	7	Do
EH107	SPT03	3.62	Brownish grey, silty clay / clayey silt with sand mixture & mica.													CI*		39	61	(Silt+Clay)	Do
EH108	UDS01	2.00	Brownish grey, silty clay / clayey silt with traces of kankars.	2.02	1.73		17 T		UNCONFD 0.0 0.0 0.0	1.817 1.849 1.839	1.84	0				CI*					Do
									REMOULD 0.0 0.0 0.0	1.242 1.286 1.268	1.26	0									
EH109	SPT02	2.45	Greyish brown, silty clay.										43	21		CI					Do
EH110	SPT03	3.40	Greyish brown, silty clay / clayey silt with mica.													SM		64	36	(Silt+Clay)	Do

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Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No.: 3401 | Sheet No.

LABORATORY ROCK TEST RESULTS

BH No.	Run No.	Depth (M)	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Slake Durability Index (%)	Hardness (based on Mohr Scale)	Soundness (%) Loss	Deformability (kg/sqcm)	Test Method
			Bulk	Dry				In-situ	Saturated							
1	1	5.75-6.00					2.748				0.83	24.72	2.50-3.00	8.25		**See the Notes
1	10	12.50-13.25	1.983	1.911	3.743	7.155	2.589	102	20	0.196	0.90	45.48	3.00-3.50		5883	Do
2	3	4.25-5.00	2.001	1.950	2.630	5.129	2.713				0.88		3.00-3.50	2.48		Do
3	5	6.00-6.75	2.117	2.045	3.560	7.278	2.605	27			0.90	29.43			1995	Do
4	2	6.75-7.50	1.817	1.804	0.724	1.307					0.94	63.28		4.90		Do
4	12	14.25-15.00	2.285	2.239	2.053	4.598	2.347	186	50	0.269	1.21		3.50-4.00	1.25	5778	Do
5	8	9.00-9.75										11.11		10.00		
6	2	4.50-5.25									0.84		3.00-3.50	4.75		
6	8	9.00-9.75										0.00		17.29		
7	15	14.25-15.00	2.222	2.185	1.693	4.021	2.619	100	17	0.170	1.00	2.25	3.00-3.50		4752	Do
8	22	19.00-19.75	2.289	2.223	1.596	3.548	2.673	122	87	0.714	3.25	61.48	3.50-4.00	8.29		Do
9	19	16.75-17.50	2.252	2.171	3.748	8.136	2.368	176	24	0.136		63.96	3.00-3.50		6020	Do
10	1	3.00-3.75	2.013	1.972	2.081	4.105	2.057				1.25			11.25		Do
11	3	5.50-6.25							15			0.00	2.50-3.00	13.49		
12	11	11.50-12.25	2.167	2.092	3.611	7.533	2.568	75	40	0.533	1.75	44.47		9.96	2726	Do
13	7	8.50-9.25	2.242	2.193	2.228	4.885	2.305				0.97		3.00-3.50			Do
14	30	25.00-25.75	2.196	2.147	2.303	4.944	2.480	120	102	0.846	4.33	92.48	3.50-4.00	5.75	5183	Do
15	16	14.75-15.50	2.225	2.156	3.179	6.855	2.610				2.15			4.29		Do
16	14	14.50-15.25	2.254	2.183	3.248	7.092	2.580		38		1.00	70.00			4433	Do
17	15	14.00-14.75	2.257	2.215	1.905	4.221	2.499				9.57	66.67	3.00-3.50	10.00		Do
18	4	6.50-7.25	2.398	2.383	0.627	1.495	2.420				0.94		3.00-3.50			Do

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CETEST

Job No. : 3401 | **Sheet No.**

BH No.	Run No.	Depth (M)	Density (gm/cc)		Water Content	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Slake Durability Index (%)	Hardness (based on Mohr Scale)	Soundness (%) Loss	Deformability (kg/sqcm)	Test Method
			Bulk	Dry	(%)			In-situ	Saturated							
18	20	18.25-19.25	2.250	2.214	1.627	3.601	2.498	147	39		4.65	72.48	3.00-3.50	11.21	4705	Do
19	19	20.50-21.25	2.165	2.094	3.367	7.052	2.675	106	41	0.386				10.63	4290	Do
20	2	5.75-6.50									0.81	11.92	2.00-2.50			Do
21	15	15.00-15.75	2.343	2.283	2.627	5.998	2.428	335			5.46	86.48	3.00-3.50	4.29	12325	Do
22	2	5.75-6.50	2.165	2.123	1.996	4.238	2.630				0.95	3.69		11.92		Do
23	15	16.50-17.25	2.449	2.409	1.660	3.259	2.692	254	142		4.42	82.36	3.50-4.00		11543	
24	8	12.25-13.00	1.949	1.882	3.561	6.701	2.017	52				39.63			1344	Do
25	8	11.25-12.00	2.159	2.114	2.143	4.531	2.680	59	25		1.00	64.44	3.00-3.50	11.25	3353	Do
26	15	16.25-17.00	2.225	2.163	2.853	6.172	2.306		47		3.21			4.82	3149	Do
27	17	15.25-16.00	2.150	2.091	2.797	5.850	2.221	86	42	0.488		31.92	3.00-3.50		2895	Do
28	3	5.50-6.50	2.068	2.041	1.346	2.747	2.098				0.84			3.36		Do
29	26	28.75-29.25	2.334	2.298	1.591	3.656	2.385	243	196	0.810	10.49	91.11	3.00-3.50	4.83	13423	Do
30	1	7.25-8.00	1.885	1.847	2.048	3.783	2.649				0.82		3.00-3.50			Do
30	8	12.50-13.25	2.169	2.132	1.713	3.652	2.213	151	27	0.179		41.48			5078	Do
31	4	6.25-7.00	1.985	1.944	2.090	4.063	2.027				0.94	49.73		3.63		Do
32	20	25.75-27.25	2.333	2.304	1.241	2.859	2.372	335	100	0.298		58.99	3.00-3.50		11441	Do
33	11	11.50-12.25	2.143	2.087	2.715	5.665	2.482				1.25	44.47	3.00-3.50	4.92		Do
34	13	12.75-13.50	2.112	2.045	3.247	6.641	2.191	102	25	0.245	1.00		3.50-4.00		3001	Do
35	3	4.75-5.50	2.110	2.078	1.565	3.252	2.419				0.94	11.43	2.50-3.0	12.00		Do
36	30	24.75-25.50	2.290	2.260	1.343	3.035	2.330	264	138	0.533		72.49	3.00-3.50		15501	Do
37	28	25.25-26.00	2.351	2.314	1.588	3.674	2.402	242	140	0.579	4.82	63.48	3.00-3.50	7.63	7559	Do
38	17	14.75-15.50	2.324	2.277	2.046	4.658	2.388	172	48	0.279					7815	Do

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand. CET

Job No. : 3401 | **Sheet No.**

BH No.	Run No.	Depth (Mt)	Density (gm/cc)		Water Content	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Slake Durability Index (%)	Hardness (based on Mohr Scale)	Soundness (%) Loss	Deformability (kg/sqcm)	Test Method
			Bulk	Dry	(%)			In-situ	Saturated							
89	21	19.00-20.00	2.390	2.337	2.241	5.237	2.751		31		0.93	74.85	3.00-3.50		5757	Do
90	22	18.25-19.00	2.163	2.146	0.762	1.637	2.336	183	75	0.410					2597	Do
91	3	5.50-6.25									0.90	0.00	2.50-3.00	15.29		Do
96	6	9.25-10.00									0.92	5.00	2.50-3.00	8.29		Do
98	2	4.25-5.00										0.00		13.00		Do
99	2	5.25-6.00	2.144	2.087	2.731	6.444	2.444				0.82	7.25	3.00-3.50	7.76		Do
100	2	4.00-4.75										0.00	3.00-3.50	14.50		Do
100	7	7.75-8.50									0.82	44.48		7.72	407	Do
109	1	3.75-4.50									0.82		2.00-2.30			Do
109	6	7.50-8.25										0.00	3.00-3.50	12.25		Do
111	9	10.00-10.75	2.171	2.133	1.818	3.877	2.660	184			0.82	63.56	3.00-3.50		6593	Do
112	26	27.50-28.30	2.290	2.261	1.304	2.947	2.639	349	87	0.248			3.50-4.00		7346	Do
113	22	18.75-19.50	2.103	1.922	9.382	18.036	2.345				0.92	63.91		4.30		Do
114	23	19.50-20.25	2.274	2.220	2.463	5.466	2.348	166	49	0.295	1.33		3.50-4.00		6902	Do
115	16	14.25-15.00	1.693	1.639	3.290	5.391					1.04	42.36		5.33		Do
116	20	17.00-17.75	2.241	2.166	3.445	7.462	2.341	144	9	0.063	1.25		3.00-3.50		407	Do
117	18	17.50-18.25	2.278	2.233	1.988	4.439	2.543	120	38	0.317		55.69	3.00-3.50	2.36	5633	Do
119	10	9.75-10.30	2.126	2.064	3.024	6.241	2.201				1.04	42.57		1.00		Do

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand CETEST

Job No. : 3401 | Sheet No.

APPARENT RESISTIVITY VALUES

ERT No. 01

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	32.14	33.53	31.76	32.08	32.38
2	2.0	25.89	30.67	28.79	26.52	27.97
3	3.0	22.63	31.87	29.43	23.20	26.78
4	4.0	25.64	33.94	27.91	28.16	28.91
5	5.0	22.63	34.89	31.74	28.29	29.39
6	7.0	23.76	36.08	32.56	19.80	28.05
7	10.0	27.03	39.60	37.09	20.12	30.96

Mean Resistivity at ERT-01 is 29.21 m.

ERT No. 02

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	47.18	49.82	43.72	45.29	46.50
2	2.0	42.86	36.70	21.62	26.40	31.90
3	3.0	28.67	20.76	36.40	19.43	26.32
4	4.0	30.67	31.93	26.40	24.64	28.41
5	5.0	30.80	28.29	30.49	28.29	29.47
6	7.0	35.64	29.48	30.36	30.80	31.57
7	10.0	37.72	32.06	28.82	33.32	32.98

Mean Resistivity at ERT-02 is 32.45 m.

ERT No. 03

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	35.16	16.10	33.34	32.70	29.33
2	2.0	30.42	27.65	35.20	27.65	30.23
3	3.0	35.46	26.03	47.15	26.40	33.76
4	4.0	32.43	27.65	41.73	41.48	35.82
5	5.0	37.72	19.17	40.23	40.86	34.50
6	7.0	29.92	24.64	61.16	42.68	39.60
7	10.0	32.69	19.49	62.23	21.37	33.95

Mean Resistivity at ERT-03 is 33.88 m.

ERT No. 04

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	23.96	26.17	21.07	21.70	23.23
2	2.0	24.51	24.51	23.00	23.88	23.98
3	3.0	26.40	26.78	26.97	27.72	26.97
4	4.0	28.91	30.67	28.66	28.16	29.10
5	5.0	29.86	40.23	33.32	29.23	33.16
6	7.0	30.36	41.36	34.76	38.72	36.30
7	10.0	31.43	39.60	37.09	40.23	37.09

Mean Resistivity at ERT-04 is 29.97 m.

Project: G/I for 3x660MW North Karanpura Super Thermal Power Project, Jharkhand CETEST

Job No. : 3401 | Sheet No.

ERT No. 05

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	21.83	21.57	23.71	20.25	21.84
2	2.0	20.74	18.60	18.60	18.23	19.04
3	3.0	17.92	16.79	18.11	18.67	17.87
4	4.0	20.11	19.86	19.36	19.36	19.67
5	5.0	21.06	20.74	19.80	18.54	20.04
6	7.0	24.64	22.88	22.88	21.12	22.88
7	10.0	23.89	23.89	27.66	24.52	24.99

Mean Resistivity at ERT-05 is 20.90 m.

ERT No. 06

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	16.17	16.23	19.00	16.23	16.91
2	2.0	16.47	16.59	17.10	17.22	16.85
3	3.0	17.54	21.50	22.63	36.59	24.57
4	4.0	21.12	26.15	23.13	20.87	22.82
5	5.0	24.83	27.66	23.26	20.74	24.12
6	7.0	27.28	30.36	26.40	27.28	27.83
7	10.0	29.54	28.29	30.80	29.54	29.54

Mean Resistivity at ERT-06 is 23.23 m.

ERT No. 07

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	18.81	19.18	20.76	19.81	19.64
2	2.0	22.75	20.87	23.00	23.63	22.56
3	3.0	24.90	26.03	25.46	25.84	25.56
4	4.0	25.14	22.63	26.65	44.50	29.73
5	5.0	26.09	26.72	28.60	29.23	27.66
6	7.0	32.56	22.44	26.40	27.72	27.28
7	10.0	33.94	30.17	33.32	32.69	32.53

Mean Resistivity at ERT-07 is 26.42 m.

ERT No. 08

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	1.0	38.43	36.92	32.27	36.48	36.03
2	2.0	23.13	14.83	15.84	15.46	17.32
3	3.0	21.50	21.12	18.48	21.50	20.65
4	4.0	19.86	21.12	18.60	25.14	21.18
5	5.0	15.40	20.74	21.37	26.40	20.98
6	7.0	20.24	26.40	25.08	28.16	24.97
7	10.0	23.89	26.40	34.57	25.14	27.50

Mean Resistivity at ERT-08 is 24.09 m.